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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service • Environmental Health Service

XUM

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g=2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie=2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 12, December 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and x rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Environmental Health Service ● Bureau of Radiological Health

Radioactive Cesium in Estuaries

Gordon K. Riel[1]

The concentration of dissolved cesium-137 from fallout in the Chesapeake Bay is on the order of 0.3 pCi/liter, while the concentration is less than 0.1 pCi/liter in the rivers and ocean that supply the Bay's water. The ratio of radiocesium concentration to salinity in the Bay is fairly independent of location and season. Brief studies elsewhere indicate that this pattern is typical of estuaries.

The Chesapeake Bay has been described as "the most valuable . . . and the most threatened estuary in the world" (*1*). Its drainage area extends into six States, and it receives agricultural, industrial, and domestic wastes from 12 million people. Knowledge of the behavior of cesium in bodies of water and drainage systems will help determine mass transfer coefficients which are needed for various types of pollution control, as well as for the control of releases from nuclear reactors planned for the bay and its tributaries. This report presents the results of studies of cesium-137 concentrations in Chesapeake Bay, in surface waters draining into it, and in nearby coastal Atlantic Ocean waters.

Table 1 presents information about the dimensions of the bay. The net water transport which flushes the bay is only about 10 percent of the tidal flow. Therefore, the residence time of water in the bay is calculated to be about a year, by dividing the total volume (75×10^9 cubic meters) by the net flow rate (2×10^3 cubic meters per second).

Table 1. Chesapeake Bay: selected data (*1*) (values are approximate)

Length	195 miles	
Width	3.4 to 35 miles	
Surface area of water:		
Bay	2,320 square miles	
Tributaries	2,120 square miles	
Mean depth:		
Bay	27.7 feet	
Bay and tributaries	21.4 feet	
Drainage area:		
Piedmont	50,600 square miles	
Coastal plain	14,300 square miles	
Total	64,900 square miles	
Number of tributaries: rivers, creeks, branches	150	
Navigable distance, tidewater	1,750 miles	
Shoreline length, bay and tidewater tributaries	4,600 miles	
Average stream discharge (*4*), cubic feet per second:	1968	1969
Susquehanna River	32,200	28,100
All rivers	60,100	54,900
Sediment discharge (*5*):		
Susquehanna River	0.96×10^6 tons/a	
Potomac River	1.4×10^6 tons/a	
Cesium-137 fallout per year (*6*):		
Per square meter	2 nCi	
Total	20 Ci	

Method

Cesium is extracted by pumping water through the inorganic exchanger, potassium hexacyanocobalt (II) ferrate (II) (KCFC) (*2*, *3*). A dip filter keeps solids out of the exchanger, and a flowmeter measures the volume of water pumped. One hundred grams of KCFC will extract 70 percent of the dissolved cesium from 600 liters of water per hour. The cesium-137 content of the KCFC is determined by gamma spectrometry, with an error (counting and systematic) of ± 20 pCi. Therefore, an accuracy of $\pm$ 0.02 pCi/liter requires a total flow of 1,400 liters or about 2½ hours pumping.

Duplicate determinations were made both with other laboratories and by analyzing the same KCFC sample repeatedly at NOL. Five out of seven samples counted by the Bureau of Commercial Fisheries Radiobiology Laboratory, Beaufort, N.C. (RBL) and 15 out of 30 samples counted by the Maryland Department of Health, Bureau of Laboratories, Baltimore, Md., agreed with our analysis within the stated error.

[1] Dr. Riel is a research physicist in the Nuclear Physics Division of the U.S. Naval Ordnance Laboratory (NOL), Silver Spring, Md. 20910.

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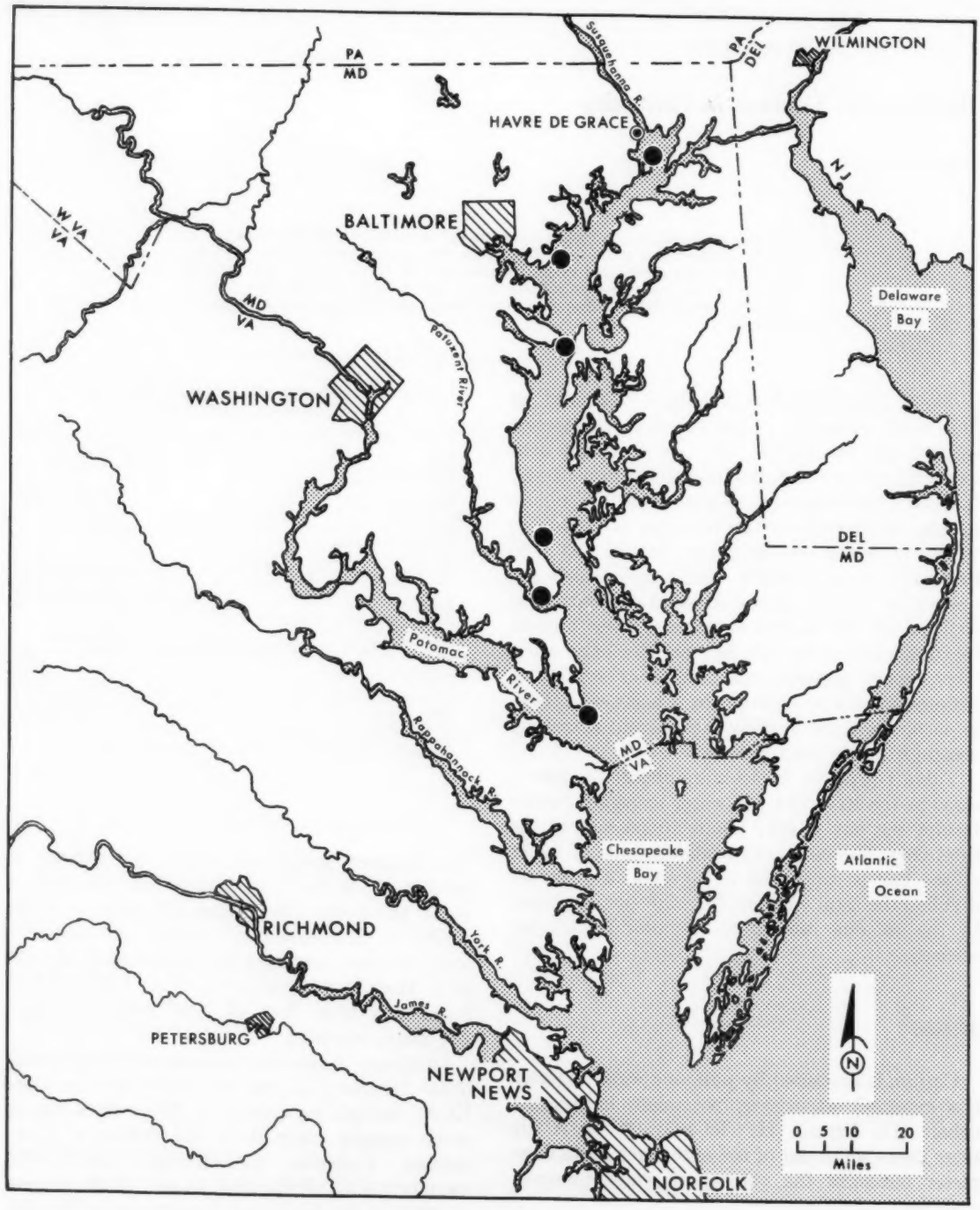

Figure 1. Chesapeake Bay sites of cesium-137 measurements

Extraction efficiency is checked frequently by pumping the water through two beds of KCFC in series. At three sites, the effluent water was acidified to ionize any cesium complexes and reanalyzed. None were found. Errors in extraction efficiency, water volume, and cesium-137 standard sources give a proportional error of about ± 20 percent.

Tests at shallow water sites near shore are influenced by rainfall and evaporation. However, by normalizing for salinity, values typical of offshore water are obtained. These are reported as cesium-137 to potassium ratios assuming that the potassium concentration is a constant fraction of salinity.

Results

Six sites, each with a pier in water 1 to 2 meters deep (figure 1 and table 2), along the western shore of the Chesapeake Bay were tested periodically from June 1968 through January 1970. Tests along the bay's ship channel (figure 2 and table 3) verified that the shore sites received typical surface water. Deep water at the bottom of the channel had only about half the concentration of cesium that surface water had. However the deep channel is narrow so most of the water is like surface water. The ratio of radiocesium to salinity is fairly constant so the bay's cesium-137 content may be estimated from the salinity distribution.

The Patuxent River (table 4) has a cesium-137 distribution similar to that of the bay; that is, the ratio of cesium-137 to salinity is about 0.002 in the surface water and about 0.001 near the bottom. At Chalk Point, where a significant portion of the river is circulated through the power plant, these ratios are reversed.

A dozen clams (*Mya arenaria*) were collected by personnel of the Chesapeake Biology Laboratory at each of these sites (table 4) during the Patuxent River test, but the cesium-137 content was undetectable. Therefore, in February 1969, they collected a bushel of clams from water with a salinity of 13.3 °/₀₀ (parts per thousand) and a cesium-137 concentration of 0.1 pCi/liter. Cesium-137 amounting to about 3 percent of the natural potassium-40 radioactivity, was detected in this large sample (table 4).

Repeated measurements in fresh water (table 5) have convinced us that little dissolved cesium-137 enters the bay that way. The concentation in fresh water does not average more than 0.01 pCi/liter, so a year's flow at 2.8×10^3 m³/s (10^5 c.f.s.) will deliver less than 1 curie of cesium-137. Mud contained less than 50 pCi cesium-137/kg wet weight so a typical discharge into the bay of 10^6 tons per year (5) would deliver less than 0.05 curies annually. These are small compared with the direct fallout deposition of about 20 curies per year.

Table 2. Cesium-137 in the Chesapeake Bay near the western shore

Site[a]	Adjacent river	Date	Salinity °/₀₀	Cesium-137 concentration	
				(pCi/liter)[b]	(pCi/g K)[c]
Spesutie Island:	Susquehanna	7/18/68	—	0.05±0.02	—
		9/11/68	1.4	.07± .02	4.4±1.3
		10/2/68	2.2	.03± .02	1.1± .8
Causeway, south side		11/1/68	4.1	.14± .04	3.0± .9
Causeway, north side		11/1/68	4.0	.07± .02	1.6± .4
Causeway, north side		6/3/69	.4	.03± .02	6 ±3
Causeway, north side		10/1/69	.6	.05± .02	9 ±2
Swans Point; Baltimore	Back	5/27/69	3.0	.06± .02	1.7± .4
		9/5/69	6.1	.27± .02	3.6± .3
Bay Bridge:		9/12/68	13.7	.22± .02	1.4± .1
		10/17/68	13.0	.12± .05	.8± .3
		5/28/69	6.8	.09± .02	1.2± .2
Calvert Beach:		7/30 & 10/30/69	13.3	.25± .01	1.6± .06
		9/16/69	14.5	.26± .02	1.5± .07
		10/3/69	16.1	.24± .02	1.3± .07
		12/18/69	15.1	.14± .02	.8± .1
Chesapeake Bay Biology Laboratory (Solomons)	Patuxent	9/10/68	15.2	.35± .02	2.0± .12
		2/18/69	15.9	.10± .02	.6± .05
		6/10/69	14.4	.26± .03	1.6± .2
		9/4/69	14.7	.29± .07	1.6± .4
Point Lookout:	Potomac	5/26/69	15.5	.18± .02	1.4± .2
		6/9/69	16.0	.22± .04	1.7± .3
		7/25/69	15.3	.27± .03	1.5± .2
		9/18/69	16.8	.30± .03	1.5± .2
		1/27/70	17.5	.33± .04	1.6± .2

[a] Ranked in direction of fresh water flow (figure 1).
[b] Proportional error is about 20 percent.
[c] 0.0117 times salinity equals grams of potassium per liter.

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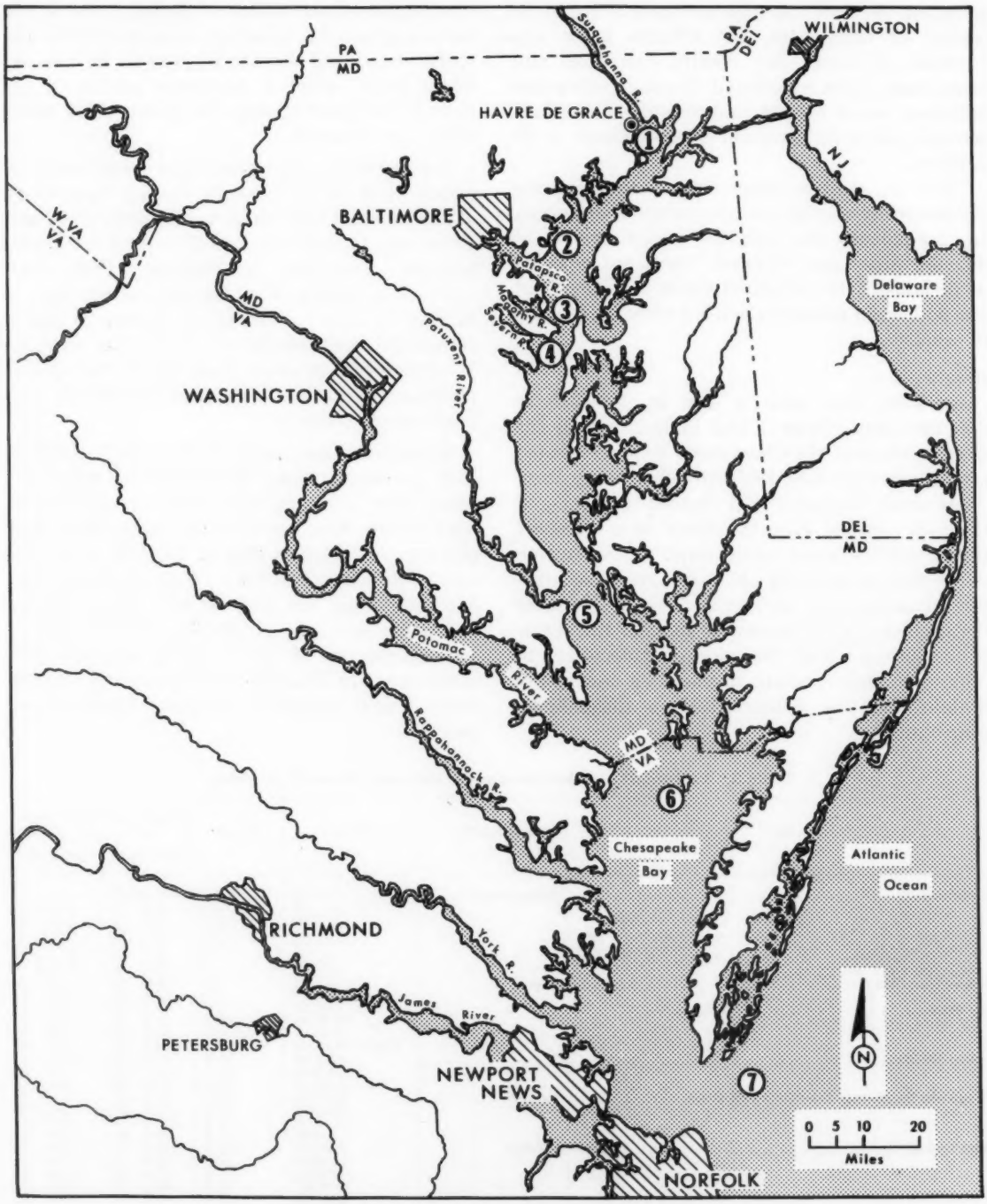

Figure 2. Chesapeake Bay cesium-137 stations, October 1968

Table 3. Cesium-137 in the Chesapeake Bay ship channel

Site[a]	Depth (feet)	Adjacent river	October 1969		Salinity °/₀₀	Cesium-137 concentration	
			Day	Hour		(pCi/liter)[b]	(pCi/g K)[c]
1	6	Susquehanna	21	1040	4.5	0.06 ±0.02	1.2 ±0.4
	Bottom		21	1140	4.5	.04 ± .03	.7 ± .5
2	6	Patapsco	21	0830	12.9	.14 ± .02	.9 ± .1
	Bottom		21	1200	7.9	.06 ± .02	.7 ± .2
3	Bottom	Magothy	21	1630	13.9	.09 ± .02	.6 ± .1
4	6	Severn	22	0750	14.8	.24 ± .02	1.4 ± .2
	105		22	0830	19.7	.12 ± .02	.6 ± .1
5	6	Patuxent	22	0940	16.0	.23 ± .02	1.2 ± .1
	110		22	1230	23.1	.18 ± .02	.7 ± .07
6	6	Potomac	22	1240	17.8	.36 ± .02	1.7 ± .1
	54		22	1645	21.0	.22 ± .02	.9 ± .1
7	6	James	23	0750	19.0	.29 ± .02	1.3 ± .09
8	6	(In ocean)	23	1240	26.5	.17 ± .02	.5 ± .07
	50		23	1340	31.1	.14 ± .03	.4 ± .09

[a] Ranked in direction of fresh water flow, see figure 2; bottom at fixed station: surface while underway.
[b] Proportional error is about 20 percent.
[c] 0.0117 times salinity equals grams of potassium per liter.

Table 4. Cesium-137 in Patuxent River[a]

Site[b]	Depth (feet)		August 1969		Salinity °/₀₀	Cesium-137 concentration	
	Start	End	Day	Hour		(pCi/liter)[c]	(pCi/g K)[d]
Milton Landing	2	2	7	1350	3.2	0.12 ±0.02	3.1 ±0.4
	35	25			3.3	.04 ± .02	.9 ± .5
Potts Point	2	2	7	1110	7.7	.14 ± .03	1.6 ± .3
	6	7			8.2	.08 ± .03	.8 ± .3
Chalk Point	2	2	8	1050	8.7	.12 ± .03	1.1 ± .3
	15	15			9.3	.22 ± .03	2.0 ± .3
Buzzard Island	2	2	8	1305	10.9	.20 ± .03	1.7 ± .2
	12	15			11.6	.19 ± .02	1.4 ± .2
Drum Cliff	2	2	6	1340	12.8	.16 ± .03	1.1 ± .2
	13	19			13.3	—	—
St. Cuthbert wharf	2	2	6	1140	13.5	.25 ± .02	1.6 ± .2
	4	8			13.7	—	—
Drum Point	2	2	6	0920	14.5	.22 ± .02	1.3 ± .1
	6	—			14.7	—	—

[a] A bushel of clams collected on 2/17/69 off Marsh Point (salinity 13.3 °/₀₀: cesium-137, 0.1 pCi/liter) contained 260 ± 20 pCi ^{137}Cs/kg dry meat, 6.2 ± 0.3 pCi ^{137}Cs/g K.
[b] Ranked in direction of fresh water flow.
[c] Proportional error is about 20 percent.
[d] 0.0117 times salinity equals grams of potassium per liter.

Table 5. Cesium-137 in the Chesapeake Bay tributary near shore

Site[a]	River	Date	Salinity °/₀₀	Cesium-137 concentration	
				(pCi/liter)[b]	(pCi/g K)[c]
Delaware City	C & D Canal	1/30/70	6.4	0.07 ±0.02	0.9 ± 0.2
Susquehanna State Park[d]	Susquehanna	4/5 & 11/68	.09	.00 ± .01	0 ±10
		5/14 & 16 and 6/10 & 11/68		.00 ± .003	—
Port Deposit[d]	Susquehanna	3/22/68	.10	.00 ± .04	0 ±30
Turkey Point	Elk	4/11/68	.10	.07 ± .4	60 ±30
Elk Neck	Elk	4/26/68	.27	.03 ± .02	9 ± 6
Elk Neck	Northeast	4/19/68	.1	.00 ± .03	0 ±20
Baltimore	Back	5/10/68	Brackish	.3 ± .07	—
Annapolis	Severn	4/23/68	Brackish	.13 ± .01	—
Highway 4	Patuxent	5/8/68	Fresh	.04 ± .02	—
		7/29/68	Fresh	.00 ± .02	
Benedict	Patuxent	7/30/68	Brackish	.3 ± .02	—
		2/18/69	13.0	.09 ± .02	.6 ± .1
Washington	Potomac	5/2 & 6/68	Fresh	.02 ± .01	—
		7/17/68	Fresh	.04 ± .03	—
		7/26/68	Fresh	.00 ± .02	—

[a] Ranked in direction of fresh water flow.
[b] Proportional error is about 20 percent.
[c] 0.0117 times salinity equals grams of potassium per liter.
[d] Other negative results (0 ± 20 pCi/sample) in Susquehanna River include filters, mixed resin, kilogram samples of mud and leaves, and 6 more extraction tests at above sites, one with nitric acid added to maintain pH = 2.

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Table 6. Cesium-137 in North Carolina estuaries

Site[a]	Body of water	August 1968		Salinity °/₀₀	Cesium 137 concentration	
		Day	Hour		(pCi/liter)[b]	(pCi/g K)[c]
Radiobiology Laboratory, Beaufort	Bogue Sound	14	1400	35.6	0.16 ±0.02	0.4 ±0.05
New Bern	Neuse River	15	1100	7.8	.28 ± .02	2.9 ± .2
Fort Point	Neuse River	15	1400	7.0	.29 ± .02	3.5 ± .3
Crotan State Forest	Neuse River	14	1100	13.1	.32 ± .02	2.1 ± .2
Great Neck Point	Neuse River	13	1240	16.2	.34 ± .02	1.8 ± .1

[a] Ranked in direction of fresh water flow.
[b] Proportional error is about 20 percent.
[c] 0.0117 times salinity equals grams of potassium per liter.

Surface water in the Neuse River was sampled from shore at four stations from New Bern downstream about 27 miles, almost to Pamlico Sound. Salinity during this test was 3 to 4 °/₀₀ higher than that normally found by RBL investigators. Concentrations of cesium-137 in the Neuse River (table 6) were somewhat higher than in the Chesapeake Bay. The cesium to potassium ratio instead of being constant was a linear function of salinity, that is: pCi/g = 0.18 (25 − salinity). The radiocesium concentration and salinity of Bogue Sound were typical of coastal ocean water.

The Savannah River (table 7) receives a little cesium-137 from the AEC Savannah River project and is the only fresh water where we have found cesium-137 concentrations of more than 0.1 pCi/liter (other than in the discharge of a nuclear reactor). At the river's mouth, the concentration was lower, indicating dilution and rapid flushing.

Table 7. Cesium-137 in Savannah River

Site[a]	Date	Salinity	Cesium-137 concentration (pCi/liter)[b]
Augusta, Ga.	1/24/68	Fresh	0.1 ±0.01
Below Savannah River plant	1/26/68	Fresh	.5 ± .05
Savannah, Ga: Ft. Pulaski	1/27/68	High tide	.1 ± .05
		Low tide	.2 ± .04

[a] Ranked in direction of fresh water flow.
[b] Proportional error is about 20 percent.

Coastal Atlantic Ocean water (table 8) shows considerable variation in cesium-137 concentration. Lower concentrations are typical of ocean water, while higher concentrations are typical of water that has remained in a shallow basin. At Indian River Inlet either condition may exist depending on the flow during the test.

Table 8. Cesium-137 in coastal Atlantic Ocean

Site	Date	Cesium-137 concentration (pCi/liter)[a]
Indian River Inlet, Delaware	1/18/67	0.10 ±0.01
	3/23/67	.24 ± .02
	3/28/67	.27 ± .02
	3/30/67	.13 ± .03
	4/20/67	.30 ± .04
	4/27/67	.07 ± .04
	5/17/67	.30 ± .05
	6/14/67	.15 ± .02
Cape Henlopen, Delaware	4/4/67	.21 ± .05
Bahamas	8/6/67	.115 ± .004
Bahamas and Gulf Stream	11/18—19/69	.083 ± .005

[a] Proportional error is about 20 percent.

Conclusions

Chesapeake Bay waters with salinity between 6 and 18 parts per thousand had cesium-137 concentrations between 0.1 and 0.4 pCi/liter. The concentration of dissolved fallout cesium-137 in fresh water averages less than 0.01 pCi/liter; in the coastal Atlantic Ocean, it is about 0.1 pCi/liter (7). The cesium-137 to potassium ratio is 1 to 2 pCi/g in the estuaries and about 0.5 pCi/g in the ocean. At salinities below 3 parts per thousand, the cesium to potassium ratio is subject to large errors because the assumption that potassium is a constant fraction of salinity does not hold for fresh water.

Two large reservoirs, the earth and the stratosphere, feed cesium-137 into the bay and will continue to do so for decades after the end of the atmospheric weapon tests. First, annual fallout directly on the bay's surface is about 2 nCi/m². Second, rain falling on 65,000 square miles of land drains into the Chesapeake Bay. So far, most of the cesium in that rain has been retained on the land because cesium is bound tightly to clay minerals. However, as these minerals wash into the bay, we may see estuarine concentrations of cesium-137 increasing even while fallout deposition

is decreasing. In salt water, sodium exchanges with cesium on clay so that part of the cesium is dissolved. To date, the cesium-137 in the Chesapeake Bay may be accounted for by the 6.5 meter average depth and 1 year's residence time:

$$(V)\frac{dc}{dt} = (2\times10^3\ \text{pCi/a}\cdot\text{m}^2)(\text{surface area}) - (Q)(C_t) = 0 \quad \cdots(1)$$

where V = average volume of bay

Q = net flow rate from the bay

C_t = cesium-137 concentration in the bay

$$\text{surface area} = (V)/(d) \quad \cdots(2)$$

where d = average depth

$$\therefore (2\times10^3)(V)/(d) = (Q)(C_e) \quad \cdots(3)$$

$$\text{or } (2\times10^3)/(d) = (Q/V)(C_e) = (1/T)C_e \quad \cdots(4)$$

where T = residence time

C_e = equilibrium cesium-137 concentration

$$\frac{(2\times10^3)(T)}{d} = C_e \quad \cdots(5)$$

$$C_e = \left(\frac{2\times10^3\ \text{pCi/a}\cdot\text{m}^2}{6.5\ \text{m}}\right)\left(\frac{1\ \text{m}^3}{10^3\ \text{liter}}\right)(1\ \text{a})$$

$$= 0.3\ \text{pCi/liter} \quad \cdots(6)$$

Fallout on the ocean surface is mixed to a depth of about 100 m, and the resulting cesium-137 concentration is about 0.1 pCi/liter. This observation suggests that the residence time for fallout cesium in the upper layer of the ocean may be on the order of:

$$1\ \text{year}\left(\frac{0.1\ \text{pCi/liter}}{0.3\ \text{pCi/liter}}\right)\left(\frac{100\ \text{meters}}{6.5\ \text{meters}}\right)$$

$$= 5\ \text{years} \quad \cdots(7)$$

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We wish particularly to thank those individuals from Pennsylvania to Georgia who allowed us access to the water from their property; that we were never refused indicates a universal interest of watermen in understanding and protecting this resource.

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Nassau County Microwave Oven Study, June 1969–March 1970

David Mafrici, Sheldon V. Bernstein, and *Charles E. Miller*[1]

The Radiological Health Section of the Nassau County Department of Health conducted a survey of microwave ovens located in Nassau County, New York. A total of 166 ovens were surveyed between June 1969 and March 1970. It was found that 23 of the 166 ovens (14 percent) exceeded the industry's standard of 10 mW/cm² during normal operation. When the door was in the process of being opened, 69 of the 166 ovens (42 percent) exceeded the standard. The owners and the manufacturers of the ovens were notified of the results of the survey, and recommendations were made for correction of deficiencies.

Microwave equipment has been in wide use by the military for many years to convey information (such as radar and communications systems), as a means of transmitting power, and for heating effects (*1*). Recently, there has been an increase in the use of microwave radiation (microwave ovens) for food preparation. Although the use of microwave ovens had predominantly been limited to the military and commercial restaurants, units are now available for home use.

The current selling price ranges from $500 to $1,000 per oven and it was estimated in 1968 that sales approximated 40,000 units per year (*2*). Should the price decrease considerably, the number of ovens sold for home use is expected to increase sharply. The advantages of microwave cooking as compared to the conventional methods of cooking include: (a) shorter cooking time; (b) uniform cooking of the food rather than cooking only from the surface; (c) less need for cleaning of utensils since only the food is heated, and (d) production of less heat thereby keeping cooking areas cooler.

Effects of microwave radiation

Microwaves produce a rapid temperature rise in food, and this same effect would occur in the human body. Microwave absorption is greatest in those tissues of the body which have a high water content. The biological effects of microwave radiation are greatest in tissues or organs which have a poor capacity to dissipate a local temperature rise. The male gonads and the lens of human eyes fall into this category. The eyes are especially susceptible and there is evidence that microwave radiation produces cataracts (*3*). There have not been any injuries reported which can be directly attributed to the use of microwave ovens; however, the potential for such injury exists (*4*). Although no official Federal standards have been promulgated,[2] the U.S. Army, Navy, and Air Force have established an exposure standard of 10 mW/cm², based on "heat tolerance and transfer capabilities of the human body" (*5*). The U.S.S.R.'s standard of 0.01 mW/cm² is based on "disruptions of the functional state of the neural and cardiovascular systems" (*5*). In the absence of official regulations, industry has accepted and used 10 mW/cm² as a voluntary emission standard.

Initial survey

As a result of discussions held with representatives of the U.S. Public Health Service, the Radiological Health Section of the Nassau County

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[2] Editors note: on October 6, 1970, emission standards for microwave ovens were published by the Bureau of Radiological Health.

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Department of Health conducted a preliminary survey of microwave ovens during June 1969 (*6*). The purpose was to determine if a problem existed with ovens leaking microwave radiation in excess of industry's own standard. Initially, this study concentrated its efforts on commercial establishments. With the cooperation of three catering firms, the locations of commercial ovens in Nassau County were obtained. In addition, one of the oven manufacturers who produced ovens solely for home use submitted a list of customers located in the county. As a result of the June survey, it was discovered that 12 percent of the ovens exceeded industry's own standard of 10 mW/cm² at 5 cm during normal operation (door closed), and 40 percent exceeded the standard while the door was in the process of being opened (interlock test).

Subsequent survey

Since the 50 ovens surveyed in June could not be considered a representative sample, it was decided to extend the project and survey as many ovens as could be located in the county. In November 1969, a formal agreement was made with the U.S. Public Health Service and the New York State Department of Health in which the Nassau County Department of Health would perform the necessary surveys (*7*). One of the prime objectives of the agreement was to collect sufficient data for use in the development of performance standards for electronic products. In addition, the collection of these data could be used for county, State, and national assessment of radiation exposure from electronic products.

Survey procedures

A total of 166 microwave ovens were surveyed; —50 during June 1969 and 116 during December 1969 to March 1970 (table 1). Sixty-one of the ovens were located in commercial establishments (such as restaurants and cafeterias); 96 were being used in the home and nine used as demonstration models.

Two different instruments were used in the June survey, the Ramcor 1200B and the Narda 8100 (table 2). The Narda instrument was eventually selected and used throughout the later survey because:

(a) it was manufactured specifically for surveying microwave ovens,
(b) the antenna is designed to minimize polarization sensitivity of the detector,
(c) the 2-inch spacer provided uniform distance from any external surface of the oven,
(d) the instrument read directly in mW/cm² rather than decibels,
(e) the larger scale face was easier to read,
(f) an audible signal could be set for any particular reading, and
(g) no warmup time was required.

Table 1. Microwave oven study, Nassau County Department of Health

Manufacturer	Dates of survey		Total
	June 1969	December 1969 to March 1970	
Amana	14	40	54
Tappan	1	32	33
Litton	18	10	28
Omnivend	13	13	26
General Electric	0	16	16
Raytheon	4	2	6
Hotpoint	0	1	1
International	0	1	1
Magic Chef	0	1	1
Summary	50	116	166

Table 2. Type of instrument used

Instrument used	Number of ovens surveyed	
	June 1969	December 1969 to March 1970
Ramcor 1200B alone	19	0
Narda 8100 alone	7	116
Ramcor and Narda	24	0

At first, each inspection was performed by a team of two public health sanitarians; however, with experience it was found that only one sanitarian was needed to conduct each inspection. A difficulty encounted at the beginning of the survey was that of obtaining lists of names and addresses of private owners of microwave ovens. For various reasons, these lists were unavailable from the oven manufacturers. However, a press release published in the local newspapers resulted in a direct response from many oven owners to the Nassau County Health Department. During the survey, various oven manufacturers compiled listings of their customers and forwarded these lists to the Health

Department. There was no problem obtaining a list of the commercial oven locations in the County since the three catering firms were very cooperative during the June 1969 and December 1969–March 1970 surveys.

The procedures used in the survey were those established by the U.S. Public Health Service (*8*) except that a 300-ml styrofoam cup was used for the water load instead of a 600-ml glass beaker. All measurements were made using a 275 ml water test load in the cooking cavity and readings were taken at 5 cm from the surface of the oven. Two sets of measurements were obtained in each survey. The first set of readings was obtained while the oven was in normal operation (door closed). These readings indicated the amount of microwave radiation leakage which could potentially be a source of continuous human expoure during operation. A second set of readings was made while the door was in the process of being opened. With the oven operating, the door was slowly opened and measurements taken until the interlock engaged and disconnected the power supply to the oven. This procedure was performed to determine the efficiency of the interlocks. This type of microwave radiation leakage is considered to be a potential source of intermittent human exposure.

Results

The survey results show that 23 of 166 ovens (14 percent) exceeded industry's standard of 10 mW/cm² during normal operation (table 3).

Table 3. Results of survey measurements, door closed (normal operation)

Manufacturer	Reading (mW/cm² at 5 cm from surface)				
	≤1	>1 ≤ 5	>5 ≤ 10	>10	Total
Amana	42	11	1	0	54
Tappan	9	12	10	2	33
Litton	8	10	4	6	28
Omnivend	4	13	2	7	26
General Electric	1	7	3	5	16
Raytheon	2	0	2	2	6
Hotpoint	1	0	0	0	1
International	1	0	0	0	1
Magic Chef	0	0	0	1	1
Total	68	53	22	23	166

When the door was in the process of being opened, 69 out of 166 ovens (42 percent) exceeded the standard (table 4).

Table 4. Results of survey measurements, door in the process of opening

Manufacturer	Readings (mW/cm² at 5 cm from surface)				
	≤1	>1 ≤ 5	>5 ≤ 10	>10	Total
Amana	9	28	11	6	54
Tappan	0	2	3	28	33
Litton	6	2	4	16	28
Omnivend	9	5	3	9	26
General Electric	2	7	1	6	16
Raytheon	2	0	1	3	6
Hotpoint	1	0	0	0	1
International	1	0	0	0	1
Magic Chef	0	0	0	1	1
Total	30	44	23	69	166

There is very little difference in the results obtained in the initial survey (50 ovens in June) and the results obtained in the survey of 166 ovens (table 5).

Table 5. Comparison of results from the initial survey of 50 microwave ovens and survey of 166 microwave ovens

Test conditions	Percent exceeding 10 mW/cm²	
	Initial June 1969 survey	June 1969 to March 1970 survey
Oven operating under normal conditions (door closed)	12	14
Oven operating with door in process of being opened	40	42

These results generally agree with those compiled by other agencies throughout the nation where microwave oven studies have been performed (*5*).

After each survey, the owner of the oven was notified of the results. When the microwave leakage was found to exceed the voluntary standard, the owner was advised to discontinue the use of the oven and to contact the manufacturer to have the oven repaired. Where the readings were between 5 and 10 mW/cm², it was recommended that the ovens be serviced to reduce the leakage. Upon completion of the survey, each oven manufacturer was notified of the results of the survey of all his ovens. The notification included a listing of the oven location, the date of survey, the model number, measurements with the door closed, and measurements with the door in the process of being opened.

Discussion

The Nassau County microwave oven survey

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revealed that some problems exist with microwave radiation leakage. On the basis of these survey results, it is recommended that a program be initiated to eliminate this unnecessary leakage. The initial phase of the program would be related to ovens that have been manufactured and are being used by the public. A second phase would relate to the manufacture of future ovens.

The initial phase, that of locating and surveying the ovens, was completed and the oven manufacturers notified of the results. It is now necessary to determine whether corrections have been made to those ovens which exceeded the industry's standard, and on this basis a followup survey is planned.

Ovens that will be manufactured in the future can be effectively controlled only by the passage of Federal legislation. The Nassau County Department of Health has recommended to the Secretary of Health, Education, and Welfare that all new microwave ovens be designed to meet a standard of 5 mW/cm^2 at 5 cm from any portion of the surface. The survey revealed that 58 percent of the ovens met industry's voluntary standard of 10 mW/cm^2 and that 45 percent were also equal to or less than 5 mW/cm^2. This is an indication that industry is capable of meeting a proposed standard of 5 mW/cm^2. In addition, a positive interlock system was recommended on all microwave ovens to insure that the power is turned off before the door is capable of being opened. If all ovens had a positive interlock system at the time of the survey, then 86 percent of the ovens would have met industry's standard of 10 mW/cm^2 and 73.5 percent would have met the Nassau County Health Department's recommended standard of 5 mW/cm^2.

The Ad Hoc Task Force Report (*9*) on microwave ovens has recommended that (based on available data on radiation leakage of microwave ovens) additional surveys be performed by industry and government. Each manufacturer plans to survey a percentage of their ovens and arrange for corrective servicing for any of the ovens which exceed industry's voluntary standard. The Radiological Health Section of the Nassau County Department of Health has completed a survey and forwarded the data to both the manufacturers and the U.S. Public Health Service. It is anticipated that these data will be used to develop performance standards and to assess the nationwide radiation exposure from microwave ovens.

Acknowledgments

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Krypton-85 Levels in the Environment Determined from Dated Krypton Gas Samples

R. E. Shuping, C. R. Phillips, and *A. A. Moghissi*[1]

A program to monitor the krypton-85 atmospheric concentrations in the United States is described, and concentrations of krypton-85 at several sites are presented. A brief description of the analytical method is given and values obtained are compared with those reported or predicted by others.

The Southeastern Radiological Health Laboratory has undertaken a program to monitor the krypton-85 concentration in the atmosphere utilizing dated krypton gas samples obtained from commercial suppliers. This program was undertaken to verify and monitor the trend of krypton-85 levels shown by Ehhalt et al. (*1*) and predicted by Coleman and Liberace (*2*). The latter predicted a dose rate of 50 millirads per year to the general population by 2060, based on a projected krypton-85 inventory. The krypton-85 content of the sample was determined using the method reported in reference 3. This method utilizes the high solubility of krypton in conventional organic liquid scintillation solutions. The gas is introduced into an evacuated glass vial fitted with a luer tapered, ground glass fitting. The vial is filled with deaerated scintillation solution and sealed with a plastic syringe hub. The vials are then counted in a liquid scintillation counter.

Since the receipt and reporting of the samples in reference 3, we have received dated krypton samples from Chester, W. Va., and Cleveland, Ohio. The samples from West Virginia were from monthly composites of gas, while those from Ohio were from quarterly composites. Three older samples of gas from Cleveland, Ohio, were received and were from yearly composites. The data obtained from these 17 samples are presented in table 1. The values in this table represent the mean of five determinations on each sample. The data in table 2 were published in reference 3 and are reproduced here for comparison. The data from both tables are presented graphically in figure 1. The dates plotted in figure 1 are at the midpoint of the collection period and the activities are reported as pCi/m^3 of dry air at standard temperature and pressure.

The solid line in figure 1 represents data published by Ehhalt et al. (*1*) in 1963 and indicates an upward trend in the krypton-85 levels. Coleman and Liberace (*2*) predicted an increase in the atmospheric levels of krypton-85 based on the anticipated use of nuclear energy. The values found during our work compare favorably with the upward trend seen by Ehhalt and the increase predicted by Coleman.

Table 1. Krypton-85 concentration in air (current SERHL data)

Sample origin	Midpoint of collection period	Radioactivity[a] (pCi/m^3)
Chester, W. Va.	6/69	14.0±0.4
	7/69	13.6± .1
	8/69	13.8± .3
	9/69	13.6± .3
	10/69	13.6± .2
	12/69	13.7± .2
	1/70	13.1± .2
	2/70	13.2± .2
Cleveland, Ohio (Site A)	1/66	11.2± .2
	7/68	13.1± .2
	5/69	14.2± .2
	8/69	14.0± .5
	12/69	14.5± .4
	3/70	14.9± .2
Cleveland, Ohio (Site B)	4/62	7.2± .4
	11/62	7.6± .1
	7/64	10.3± .2

[a] Standard deviation calculated at the 95-percent confidence level. Mean of five determinations.

[1] Mr. Shuping and Mr. Phillips are with the Southeastern Radiological Health Laboratory, Montgomery, Ala., and Dr. Moghissi is with Southwestern Radiological Health Laboratory, Las Vegas, Nev.

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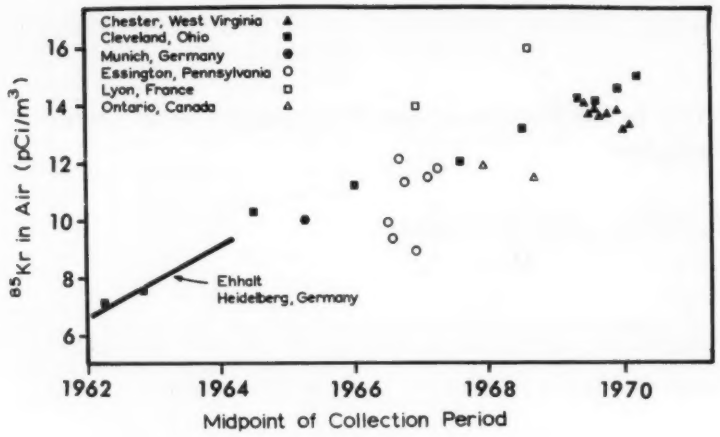

Figure 1. Krypton-85 concentration in air (including data of Ehhalt et al.)

Table 2. Krypton-85 concentration in air (from reference *3*)

Sample origin	Midpoint of collection period	Radioactivity[a] (pCi/m^3)
Munich, Germany	4/65	10.1±0.2
Essington, Pa.	7/66	9.9± .4
	8/66	9.3± .3
	9/66	12.1± .5
	10/66	11.3± .4
	12/66	8.9± .4
	2/67	11.5± .6
	4/67	11.8± .4
Lyon, France	12/66	13.9± .4
	8/68	15.9± .6
Cleveland, Ohio	8/67	12.0± .7
Ontario, Canada	12/67	11.8± .5
	9/68	11.4± .2

[a] Standard deviation calculated at the 95-percent confidence level. Mean of at least five determinations.

We plan to continue this project and will publish atmospheric krypton-85 concentrations periodically in this journal.

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SECTION I. MILK AND FOOD

Milk Surveillance, August 1970

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabol-

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Figure 1. Milk sampling networks in the Western Hemisphere

ically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 20 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. Keeping these possible differences in mind, integration of the data from the various networks can be undertaken.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable ($X \leq \overline{X} \pm 2\sigma$)	Warning level ($\overline{X} \pm 2\sigma < X < \overline{X} \pm 3\sigma$)	Unacceptable ($X \geq \overline{X} \pm 3\sigma$)	Total
Strontium-89 High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137: High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

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and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that, for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below

Radiation Protection Guides (*8*, *9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result due to exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 2 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data, one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10*, *11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 3 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 3 are milk concentrations for each

Table 2. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium–89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium–90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200– 2,000
	Bone marrow	[c] .5	.17				
Iodine–131	Thyroid	1.5	.5	100	0–10	10–100	100– 1,000
Cesium–137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium–89, strontium–90—general population; iodine–131—children 1 year of age; cesium–137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.
[d] For strontium–89 and strontium–90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

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Table 3. Protection Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium–89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium–90	Bone marrow			[c] 51,000
Cesium–137	Whole body			[c] 720,000
Iodine–131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium–89 and cesium–137 is the same as dose in first year; total dose from strontium–90 is 5 times strontium–90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

of the radionuclides considered, in the absence of others, which, if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 4 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and State stations is shown in figure 2. The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 4, surveillance results are given for strontium-90, iodine-131, and cesium-137 for August 1970 and the 12-month period, September 1969 to August 1970. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 4 since levels at the great majority of the stations for August 1970 were below the respective practical reporting levels. Table 5 gives monthly averages for those stations at which strontium-89 was detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 2), levels in milk for this radionuclide are

Table 4. Concentration of radionuclides in milk for August 1970 and 12-month period, September 1969 through August 1970

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	6	0	0	14	9
Alaska:	Palmer[c]	P	7	5	0	0	16	6
Ariz:	Phoenix[c]	P	0	1	0	0	0	0
Ark:	Little Rock[c]	P	14	13	0	0	18	17
Calif:	Sacramento[c]	P	0	1	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	16	19	0	0	6	20
	Fresno	P	1	2	0	0	0	3
	Humboldt	P	5	5	0	0	0	6
	Los Angeles	P	2	2	0	0	0	2
	Mendocino	P	3	3	0	0	0	3
	Sacramento	P	3	3	0	0	0	3
	San Diego	P	2	2	0	0	0	1
	Santa Clara	P	3	2	0	0	0	2
	Shasta	P	2	3	0	0	0	3
	Sonoma	P	3	3	0	0	0	3
Colo:	Denver[c]	P	NA	5	0	0	0	1
	West	R	(d)		(e)0	0	(e)0	4
	Northeast	R	(d)		NS	0	NS	0
	East	R	(d)		NS	0	NS	0
	Southeast	R	(d)		(e)0	0	(e)0	0
	South Central	R	(d)		NS	NS	NS	NS
	Southwest	R	(d)		(e)0	0	(e)0	6
	Northwest	R	(d)		37	0	(e)0	0
Conn:	Hartford[c]	P	NA	7	0	0	22	12
	Central	P	8	7	0	0	16	13
Del:	Wilmington[c]	P	NA	8	0	0	12	7
D.C:	Washington[c]	P	NA	7	0	0	17	7
Fla:	Tampa[c]	P	6	6	0	0	42	51
	West	R	5	10	0	0	0	21
	North	R	12	11	0	0	36	25
	Northeast	R	4	6	0	0	19	40
	Central	R	6	7	0	0	80	55
	Tampa Bay area	R	5	7	0	0	46	51
	Southeast	R	5	7	0	0	69	73
Ga:	Atlanta[c]	P	NS	10	NS	0	NS	17
Hawaii:	Honolulu[c]	P	3	2	0	0	0	0
Idaho:	Idaho Falls[c]	P	5	5	0	0	0	4
Ill:	Chicago[c]	P	7	8	0	0	12	9
Ind:	Indianapolis[c]	P	NA	8	0	0	13	5
	Northeast	P	9	9	0	1	15	14
	Southeast	P	12	12	0	0	20	8
	Central	P	8	9	0	0	15	9
	Southwest	P	11	11	0	0	15	12
	Northwest	P	11	10	0	0	15	15
Iowa:	Des Moines[c]	P	NA	6	0	0	0	2
	Iowa City	P	NS	9	NS	0	NS	9
	Des Moines	P	11(4)	7	0(4)	0	6	6
	Spencer	P	7	5	0	0	0	5
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NA	8	0	0	0	1
	Coffeyville	P	7	8	NA	0	NA	2
	Dodge City	P	13	7	NA	0	NA	0
	Falls City	R	ND	14	NA	0	NA	0
	Hays	P	10	12	NA	1	NA	1
	Kansas City	P	ND	8	NA	0	NA	0
	Topeka	P	15	9	NA	0	NA	0
	Wichita	P	13	8	NA	0	NA	2
Ky:	Louisville[c]	P	NS	8	NS	0	NS	4
La:	New Orleans[c]	P	14	15	0	0	22	18
Maine:	Portland[c]	P	NA	10	0	0	27	22
Md:	Baltimore[c]	P	NA	8	0	0	13	7
Mass:	Boston[c]	P	10	10	0	0	25	21
Mich:	Detroit[c]	P	NA	8	0	0	15	9
	Grand Rapids[c]	P	NA	9	0	0	23	12
	Bay City	P	NS	7	NS	0	NS	9
	Charlevoix	P	12(4)	12	(e)0(5)	0	17(5)	17
	Detroit	P	7	8	(e)0	0	20	7
	Grand Rapids	P	10	9	(e)0	0	14	11
	Lansing	P	8	9	(e)0(2)	0	20	15
	Marquette	P	12(3)	13	(e)0(3)	0	19	23
	Monroe	P	6(2)	6	(e)0(2)	0	0	4
	South Haven	P	7(3)	8	(e)0(5)	0	10	8
Minn:	Minneapolis[c]	P	NA	10	0	0	15	8
	Bemidji	P	7	12	0	0	27	23
	Mankato	P	4	5	0	0	15	11
	Rochester	P	7	7	0	0	16	11
	Duluth	P	6	15	0	0	37	27
	Worthington	P	11	5	0	0	0	0
	Minneapolis	P	NA	10	0	0	NA	14
	Fergus Falls	P	7	7	0	0	2	12
	Little Falls	P	19	10	0	0	104	28

See footnotes at end of table.

Table 4. Concentration of radionuclides in milk for August 1970 and 12-month period, September 1969 through August 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Miss:	Jackson[c]	P	11	12	0	0	23	12
Mo:	Kansas City[c]	P	NA	8	0	0	0	2
	St. Louis[c]	P	NA	8	0	0	0	3
Mont:	Helena[c]	P	NA	5	0	0	5	6
Nebr:	Omaha[c]	P	NA	6	0	0	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0	0	0
N.H:	Manchester[c]	P	NA	8	0	0	38	17
N.J:	Trenton[c]	P	NA	8	0	0	15	8
N. Mex:	Albuquerque[c]	P	NA	3	0	0	0	0
N.Y:	Buffalo[c]	P	8	7	0	0	16	8
	New York City[c]	P	NA	9	0	0	29	15
	Syracuse[c]	P	NA	7	0	0	19	11
	Albany	P	8	4	0(4)	0	(e)0(4)	0
	Buffalo	P	0	0	0	0	(e)0	0
	Massena	P	10	6	0(2)	0	40(2)	0
	Newburg	P	10	7	0(4)	0	(e)0(4)	0
	New York City	P	12	8	0	0	22	0
	Syracuse	P	7	3	0(2)	0	(e)0(2)	0
N.C:	Charlotte[c]	P	NA	11	0	0	20	13
N. Dak:	Minot[c]	P	NA	9	0	0	13	15
Ohio:	Cincinnati[c]	P	NA	8	0	0	0	4
	Cleveland[c]	P	NA	9	0	0	13	8
Okla:	Oklahoma City[c]	P	NA	6	0	0	0	6
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Oreg:	Portland[c]	P	4	6	0	0	0	6
	Baker	P	(d)		(e)0	0	(e)0	2
	Coos Bay	P	(d)		(e)0	0	(e)0	13
	Eugene	P	(d)		(e)0	0	(e)0	3
	Medford	P	(d)		(e)0	0	26	10
	Portland composite	P	(d)		(e)0	0	(e)0	8
	Portland local	P	(d)		(e)0	0	(e)0	8
	Redmond	P	(d)		(e)0	0	(e)0	3
	Tillamook	P	(d)		(e)0	0	37	13
Pa:	Philadelphia[c]	P	NA	9	0	0	0	6
	Pittsburgh[c]	P	NA	10	0	0	18	11
	Dauphin	P	8	7	0	3	15	13
	Erie	P	12	12	0	5	41	27
	Philadelphia	P	11	8	0	3	19	13
	Pittsburgh	P	15	11	0	2	22	20
R.I:	Providence[c]	P	NA	8	0	0	19	16
S.C:	Charleston[c]	P	12	10	11	1	25	21
S.Dak:	Rapid City[c]	P	NA	7	0	0	10	4
Tenn:	Chattanooga[c]	P	NA	9	0	0	16	12
	Memphis[c]	P	NA	9	0	0	11	6
	Chattanooga	P	7	10	0	0	13	13
	Clinton	P	8	13	0(2)	0	14(2)	14
	Knoxville	P	5	8	0(2)	0	14(2)	8
	Nashville	P	6	8	0	0	0	7
	Fayetteville	P	12	13	0(2)	0	10(2)	11
Tex:	Austin[c]	P	NA	2	0	0	0	3
	Dallas[c]	P	NA	6	0	0	0	7
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	2	4	0	0	0	2
	El Paso	R	NA	3	0	0	10	2
	Fort Worth	R	NS	5	NS	0	NS	2
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	NS	8	NS	0	NS	11
	Lubbock	R	4	4	0	0	0	0
	Midland	R	NS	3	NS	0	NS	0
	San Antonio	R	NS	4	NS	0	NS	0
	Texarkana	R	NS	8	NS	0	NS	3
	Tyler	R	11	15	0	0	25	17
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	7	9	0	0	0	5
Utah:	Salt Lake City[c]	P	6	5	0	0	16	5
Vt:	Burlington[c]	P	NA	8	0	0	14	13
Va:	Norfolk[c]	P	NA	10	0	0	12	9
Wash:	Seattle[c]	P	NA	6	0	0	0	3
	Spokane[c]	P	NA	6	0	0	0	2
	Benton County	R	NS	0	NS	0	NS	0
	Franklin County	R	0	2	0	0	0	3
	Sandpoint, Idaho	R	12	10	0	0	41	23
	Skagit County	R	7	6	0	0	20	11
W. Va:	Charleston[c]	P	10	8	0	0	3	4
Wisc:	Milwaukee[c]	P	NA	6	0	0	16	10
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

Table 4. Concentration of radionuclides in milk for August 1970 and 12-month period, September 1969 through August 1970—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA								
Alberta:	Calgary	P	[c] NA		[d]		12	18
	Edmonton	P	NA		[d]		21	17
British Columbia:	Vancouver	P	NA		[d]		24	28
Manitoba:	Winnipeg	P	NA		[d]		29	24
New Brunswick:	Frederickton	P	NA		[d]		23	20
Newfoundland:	St. Johns	P	NA		[d]		60	37
Nova Scotia:	Halifax	P	NA		[d]		26	20
Ontario:	Ottawa	P	NA		[d]		18	14
	Sault Ste. Marie	P	NA		[d]		42	28
	Thunder Bay	P	NA		[d]		42	28
	Toronto	P	NA		[d]		15	10
	Windsor	P	NA		[d]		11	10
Quebec:	Montreal	P	NA		[d]		23	18
	Quebec	P	NA		[d]		30	27
Saskatchewan:	Regina	P	NA		[d]		12	14
	Saskatoon	R	NA		[d]		23	12
CENTRAL AND SOUTH AMERICA:								
Colombia:	Bogota	P	0	0	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	3	5	0	0	55	93
Venezuela:	Caracas	P	3	1	0	0	0	0
Canal Zone:	Cristobal[e]	P	NA	1	0	0	3	9
Puerto Rico:	San Juan[e]	P	NA	3	0	0	14	6
PMN Network average[f]			7	7	0	0	10	8

[a] P, pasteurized milk; R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] Radionuclide analysis not routinely performed.
[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter
[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [e].
[g] Monthly samples were collected and composited for quarterly analysis of strontium-90.
NA, no analysis.
NS, no sample collected.

Table 5. Strontium-89 in milk, August 1970

Sampling location	Radionuclide concentration (pCi/liter)
Calif: Del Norte (State)	5
Kans: Coffeyville (State)	12
N.Y.: Massena (State)	5(2)
Tenn: Chattanooga (State)	6
Knoxville (State)	31
Nashville (State)	6
Fayetteville (State)	6
Colombia: Bogota (PAHO)	10
Chile: Santiago (PAHO)	20

of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 19 pCi/liter in the United States for the month of August 1970, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif.) representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 2). Cesium-137 monthly averages ranged from 0 to 104 pCi/liter in the United States for the month of August 1970, and the highest 12-month average was 73 pCi/liter (Southeast Fla.) representing 2.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting levels with the following exceptions: Colo., Northwest (State) 37 pCi/liter and S.C., Charleston (PMN) 11 pCi/liter.

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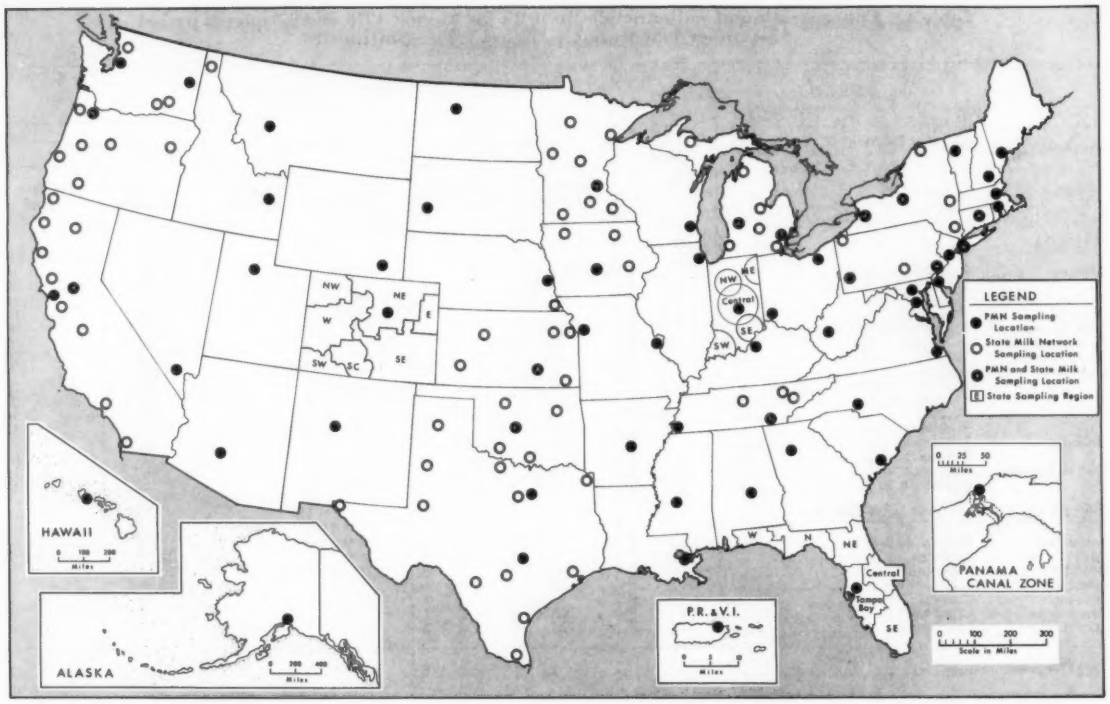

Figure 2. State and PMN milk sampling locations in the United States

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Radiological Health Services
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Connecticut State Department of Health

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Bureau of Environmental Sanitation
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Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Nuclear Engineering
New York State Department of Environmental Conservation

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Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

XUM

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Issue
California Diet Study	April–December 1969 and January–June 1970	November 1970
Institutional Diet Samples	January–March 1970	November 1970
Strontium-90 in Tri-City Diets, *HASL*	June–December 1969	June 1970

1. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July-December 1969

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Cesium-137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet for July–December 1969. Results representative of the total daily intake for the radionuclides observed are presented in table 3.

Table 1. Foods included in standard diet

Bread, white—8 slices	Ice cream—½ pint
Butter—½ stick	Lettuce, washed—4–5 leaves
Carrots, scraped—½ cup	Milk—3 cups
Celery, washed and trimmed—3 stalks	Oatmeal—uncooked—43 grams
Cookies, 4	Orange—1
Cottage cheese—2/3 cup	Peanut butter—2 ½ tablespoons
Cupcakes, 2	Pears, canned—2 halves with juice
Egg, 1	Potatoes, washed, not peeled—2
Green beans, washed—½ cup	Sugar—5 tablespoons
Ham, 85 grams	Tomato juice—113 grams
Hamburger, 227 grams	Tuna fish, drained—43 grams

Table 2. Radionuclide concentrations in Connecticut standard diet[a], July–December 1969

Month (1969)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
July	2.1	8.5	10
August	NA	NA	NA
September	2.0	5.1	20
October	NA	NA	NA
November	NA	NA	NA
December	2.1	7.7	20

[a] All strontium-89 values were <3 for this period.
NA, no analysis.

In order to evaluate general trends, the strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] July–December 1969

Month (1969)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
July	6.4	26.9	40
August	NA	NA	NA
September	6.8	17.1	50
October	NA	NA	NA
November	NA	NA	NA
December	7.0	25.3	70

[a] All strontium-89 values were <3 for this period.
NA, no analysis.

REFERENCE

(1) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1969	February 1970

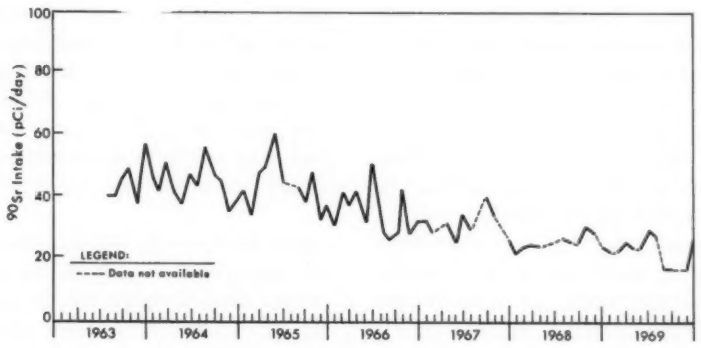

Figure 1. Strontium-90 intake in Connecticut standard diet 1963–December 1969

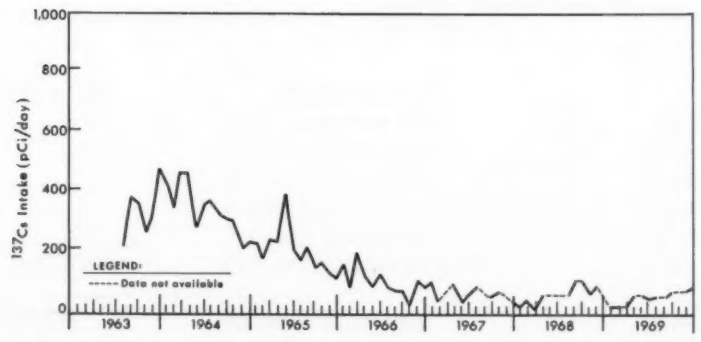

Figure 2. Cesium-137 intake in Connecticut standard diet 1963–December 1969

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SECTION II. WATER

The Public Health Service, the Federal Water Quality Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	July–December 1968	August 1970
Minnesota	January–June 1969	January 1970
New York	January–June 1969	June 1970
Kansas	January–December 1969	September 1970
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	January–December 1969	July 1970
Tritium in Surface Water	January–June 1970	November 1970
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidence for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

XUM

INTERSTATE CARRIER DRINKING WATER ANALYSIS PROGRAM, 1967–1969

Bureau of Water Hygiene and *Bureau of Radiological Health*
U.S. Public Health Service

The routine surveillance of finished drinking water from public drinking water supplies has been a project of the Public Health Service's Bureau of Water Hygiene[1] since 1960, in partial fulfillment of the requirements as set forth in Subpart J of the Interstate Quarantine Regulation (*1*) most commonly referred to as the Public Health Service Drinking Water Standards. The basic network for this activity is approximately 665 water supplies (serving over half of the U.S. population with access to public water systems) which provide water for use by interstate carriers. Laboratory support is provided by the Northeastern, Southeastern, and Southwestern Radiological Health Laboratories of the Bureau of Radiological Health. For the most part, samples were composited over a 14-day period, taking 90 milliliters three times during the operating day; however, as indicated in table 1, many samples were also taken as a single grab sample. In many cases where a water system receives raw water from more than one source, the finished drinking water derived from each source has been examined.

The drinking water standards for radionuclides are conservative in their requirements, so that the total intake of these radionuclides from all sources is not likely to result in an intake greater than the guidance levels given by the Federal Radiation Council (*2*)

The standards provide for the approval of water supplies, based on their radionuclide content, when the water does not contain more than 3 pCi/liter of radium-226 or 10 pCi/liter of strontium-90. In the absence of strontium-90, and in the absence of alpha emitters, the water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter.

However, a water supply may be approved when the limits prescribed above are exceeded if it can be demonstrated by surveillance that the total intake of radioactivity from all sources is within the guidance for control action recommended by the Federal Radiation Council. When mixtures of radionuclides are present, the relative contribution of each radionuclide to the total intake of the individual should be considered when evaluating the exposure.

Table 1 provides the results of the radiological analyses and table 2 is a summary of the results. It should be noted that the interstate carrier water samples for March through October 1969 were collected in conjunction with the Bureau of Water Hygiene's Community Water Supply Study.

[1] Formerly the Water Supply and Sea Resources Program, National Center for Urban and Industrial Health.

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Table 1. Radiological analyses of Interstate Carrier water supplies, 1967–1969[a]

	Sampling location	Sampling periods	Total radium (pCi/liter)	Radium-226 (pCi/liter)	Strontium-90 (pCi/liter)	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
						Dissolved	Suspended	Dissolved	Suspended
Ala:	Anniston	5/3/67	0		0	0	0	0	0
	Flomaton	10/28/68				0	0	0	0
	Mobile	8/21–9/4/67	0		0				
	Montgomery (N. Court Street)	4/29/68				0	0	0	0
	Montgomery (Day Street)	4/29/68				0	0	0	0
	Montgomery (Perry Plant)	4/30–5/15/68				0	0	6	0
	Prichard	8/22–9/5/67	0		0				
	Sheffeld	5/3/67	0		0	0	0	3	0
Alaska:	Anchorage	9/19/67				0	0	6	0
	Fairbanks (Treatment Plant)	9/27/67				2	0	0	0
	Fairbanks (Sally's Catering)	9/27/67				0	0	4	0
	Fairbanks (International airport)	9/27/67				0	0	4	0
	Juneau (Airport facility)	9/27/67				0	0	4	0
	Juneau (Port facility)	9/29/67				0	0	0	0
	Ketchikan	10/2/67				0	0	3	0
Ark:	Fayetteville	10/9/68				0 (total)		0 (total)	
	Ft. Smith	10/8/68				0 (total)		3 (total)	
	Helena	10/9/68				0 (total)		3 (total)	
	Little Rock (Little Rock Water works)	10/1/68				0 (total)		3 (total)	
	Little Rock (Ozark Pt. Water plant)	10/1/68				0 (total)		3 (total)	
	W. Memphis	9/25/68				0 (total)		0 (total)	
Calif:	Barstow	4/15/69		.3		7 (total)		3 (total)	
	Colton	3/20/69				2 (total)		8 (total)	
	Ontario	3/25/69				0 (total)		6 (total)	
	San Bernardino (7th Street plant)	4/14/69				2 (total)		3 (total)	
	San Bernardino (South-end Devil Canyon)	4/15–4/28/69				0 (total)		5 (total)	
	Yermo	4/9/69		.2		11 (total)		4 (total)	
Colo:	Durango	6/21/68				0 (total)		0 (total)	
	Pueblo	6/11/69		0		6 (total)		10 (total)	
Del:	Stanton	4/27–5/7/67			0	0	0	15	0
	Wilmington	5/17–5/31/67				0	0	0	0
Fla:	Bay County	3/6–3/20/68				0	0	0	0
	Cocoa	6/22–7/6/67	7.2	1.2	0				
	Orlando (McCoy Air Terminal)	2/3/69				0	0	0	0
	Orlando (Nubar Industries)	2/6/69				0	0	3	0
	Orlando (Utilities Co. Plant)	2/15–2/19/69				0	0	0	0
	Panama City	3/5/68				0	0	3	0
	Pensacola	12/5–12/12/68				0	0	4	0
	Port St. Joe	3/7–3/21/68				0	0	0	0
	St. Petersburg	10/1–10/2/68				0	0	0	0
	Tallahassee	3/7/68				0	0	0	0
	Tampa	10/14/68				0	0	0	0
	Tampa	10/5–10/29/68				0	0	4	0
	Tribly	10/9/68				0	0	0	0
	Wildwood	9/26/67				0	0	0	0
Ga:	Albany	3/15–3/16/67	3.0		0	0	0	3	0
	Albany (Light and Gas)	3/15–3/16/67	0		0	0	0	3	0
	Macon	3/4–3/28/67	1.6		0	0	0	0	0
Ill·	Argo	9/10–9/24/68				0	0	3	0
	Beardstown	8/6–8/20/68				0	0	7	0
	Bedford Park	9/7–9/21/68				0	0	0	0
	Cairo	5/17–5/31/67				0	0	4	0
	Carbondale	5/22–6/4/67				0	0	7	0
	Danville	9/4–9/18/68				0	0	4	0
	Downer's Grove	2/23–3/5/67			0	0	0	53	4
	Franklin Park	10/22–11/4/68				0	0	0	0
	Harrisburg	9/30–10/13/68				0	0	4	0
	Hartford	8/30–9/12/68				0	0	3	0
	Lemont	7/24–8/12/68		11.9	0	7	0	31	0
	Lemont	1/27–2/13/69		11.6	0	38	0	47	0
	Moline	5/1–5/14/67				0	0	8	0
	Mt. Vernon	11/8–11/22/68				0	0	0	0
	Orland Park	7/24–8/7/68				0	0	3	0
	Rock Island	4/28–5/12/67		0		3	0	6	0
	Rosemont	9/5–9/19/68				0	0	0	0
	Springfield	7/18–8/11/68				0	0	3	0
	Vandalia	8/8–8/22/68				0	0	0	0
Ind.	Middlebury	10/29/68				0	0	0	0
	W. Laffayette	9/20–10/7/68				0	0	0	0
Ky:	Covington	3/5–3/19/69				0 (total)		0 (total)	
	Winston Park	3/6–3/19/69				0 (total)		0 (total)	

See footnote at end of table.

Table 1. Radiological analyses of Interstate Carrier water supplies, 1967–1969—Continued

Sampling location	Sampling periods	Total radium (pCi/liter)	Radium-226 (pCi/liter)	Strontium-90 (pCi/liter)	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
					Dissolved	Suspended	Dissolved	Suspended
La: Chalmette	6/19–7/2/69		0	0	0 (total)		6 (total)	
Gretna	6/16–6/29–69		0	0	0 (total)		5 (total)	
Madisonville	6/23/69				0 (total)		0 (total)	
New Orleans	6/20–7/3/69				0 (total)		5 (total)	
New Orleans	6/23–7/6/69				0 (total)		5 (total)	
New Orleans	6/19–7/2/69				0 (total)		5 (total)	
Westwego	6/17–6/30/69		0	0	0 (total)		6 (total)	
Md: Cambridge (Magothy aquifer)	11/4/69				0	0	4	0
Cambridge (Piney Point aquifer)	11/4/69				0	0	7	0
Piney Point	11/3/69				0	0	7	0
Sparrow Point	11/6/69				0	0	3	0
Williamsport	3/12–4/3/68				0	0	2	0
Mich: Calumet	8/31–9/13/68				0	0	0	0
Channing	9/2–9/14/68				0	0	5	0
Detroit	8/14–8/28/68				0	0	3	0
Elberta	6/2–7/11/67				0	0	0	0
Holland	6/29–7/12/67				0	0	0	0
Houghton	9/23–10/7/68				0	0	0	0
Kent County	7/6–7/25/67				0	0	0	0
Muskegon	6/27–7/11/67				0	0	0	0
St. Joseph	9/3–9/16/68				0	0	4	0
Wyoming	6/28–7/11/67				0	0	3	0
Miss: Gulfport (30th Avenue well)	12/6/67				0	0	0	0
Gulfport (West pier)	12/7/67				0	0	0	0
Greenville	12/7/67				0	0	4	0
Jackson	3/25/68				0	0	2	0
Meridian	3/27/68				0	0	0	0
Moss Point	4/15/68				0	0	7	0
Natchez	3/26/68				0	0	2	0
Pascagoula	3/28/67	2.0		0	0	0	0	0
Pascagoula (Bayou Cosotte)	3/28/67	1.3		0	0	0	3	0
Pascagoula	3/29/67	2.2		0	0	0	2	0
Pascagoula (Jackson Co. Port Authority)	3/29/67	2.2		0	0	0	3	0
Pascagoula (Bayou Cosotte-Standard Oil)	3/30/67	1.7		0	0	0	3	0
Pascagoula (Bayou Cosotte–Coastal Chemical)	3/30/67	1.3		0	0	0	3	0
Pascagoula (Ingalls Shipyard)	3/31/67	0		2	0	0	5	0
Mo: East St. Louis	7/7–7/21/67				0	0	3	0
Kansas City	6/12–6/25/69				0 (total)		6 (total)	
Mont: Butte	5/27/68				4 (total)		3 (total)	
Butte (Basin Creek supply)	9/25/68			0	0 (total)		0 (total)	
Butte (Big Hole River supply)	9/25/68			0	0 (total)		0 (total)	
Butte (Moulton supply)	9/25/68			0	0 (total)		0 (total)	
N.J: Atlantic City	12/8–12/22/67				0	0	0	0
Camden	2/19/69				0	0	0	0
Hoboken	6/6/68				0	0	0	0
Jersey City	9/6/68				0	0	4	0
Trenton	2/26/68				0	0	0	0
N. Mex: Albuquerque (Vol Andia well field 204)	7/8/68				0 (total)		5 (total)	
Albuquerque (Love well field 205)	7/8/68				0 (total)		4 (total)	
Albuquerque (San Jose well field 206)	7/10/68				0 (total)		8 (total)	
Albuquerque (Burton booster station 207)	7/8/68				0 (total)		4 (total)	
Albuquerque (Atrisco booster station)	7/10/68			0	5 (total)		11 (total)	
Albuquerque (Griegos booster station 209)	7/9/68				3 (total)		7 (total)	
Albuquerque (Daranas booster station 210)	7/9/68				3 (total)		7 (total)	
N.Y: Croton	5/27/69				0 (total)		3 (total)	
Lynbrook	7/29/69				0 (total)		3 (total)	
Lynbrook	7/29–8/12/69				0 (total)		0 (total)	
New York (East View)	6/26–7/9/69				0 (total)		0 (total)	
New York (North Castle)	6/26–7/9/69				0 (total)		6 (total)	
New York (Gramsville)	6/23–7/7/69				0 (total)		0 (total)	
New York (Croton watershed)	7/15–7/29/69				0 (total)		4 (total)	
New York (Croton watershed)	7/16–7/30/69				0 (total)		3 (total)	

See footnote at end of table.

Table 1. Radiological analyses of Interstate Carrier water supplies, 1967–1969—Continued

Sampling location	Sampling periods	Total radium (pCi/liter)	Radium-226 (pCi/liter)	Strontium-90 pCi/liter)	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
					Dissolved	Suspended	Dissolved	Suspended
N.Y. (continued)								
New York (Croton Lake Gate house)	7/15–7/28/69				0 (total)		0 (total)	
New York (Ashokan Reservoir)	6/23–7/7/69				0 (total)		0 (total)	
New York (Catskill Aqueduct, Pleasantville)	6/26–7/9/69				0 (total)		0 (total)	
Peekskill	5/23–6/5/69				0 (total)		0 (total)	
Port Jefferson	9/8/69			0	0 (total)		23 (total)	
Rochester	4/22–5/6/68				0	0	4	0
Rochester	4/23–5/7/68				0	0	3	0
Rome	10/25–11/5/67				0	0	0	0
Whitehall	10/22/68				0	0	0	0
Yonkers	7/9–7/22/69				0 (total)		0 (total)	
N.C: Durham	8/8–8/22/68				0	0	3	0
Greensboro	7/25–8/8/68				0	0	5	0
Ohio: Akron	10/10–10/31/68				0	0	0	0
Ashtabula	5/4–5/17/67				0	0	7	0
Canton-Akron (Airport)	10/8–10/22/68				0	0	0	0
Cincinnati	3/3–3/16/69				0 (total)		0 (total)	
Conneaut	5/8/67				0	0	4	0
Dayton	3/15–3/29/67			0	0	0	42	0
Fairport Harbor	5/10–5/23/67				0	0	4	0
Marietta	11/13–11/27/68				0	0	0	0
Oregon	3/8–3/22/67			0	0	0	30	0
Portsmouth	11/14–11/28/68				0	0	0	0
Sandusky	3/7–3/21/67			0	0	0	3	7
Vandalia	3/10/67				0	0	4	3
Wellsville	10/8–10/21/68				0	0	0	0
Youngstown	6/11/67				0	0	4	0
Okla: Alva	10/9/68				0 (total)		3 (total)	
Lawton	10/21/68				3 (total)		11 (total)	
Tulsa	10/25/68				0 (total)		4 (total)	
Pa: Altoona	11/20/68				0	0	3	0
Reading	3/21–3/31/68				0	0	0	0
Williamsport	8/21–9/3/68				0	0	0	0
S.C: Abbeville	2/11–2/24/67	0		0	0	0	5	0
Cayce	2/17–3/3/67	0		3	0	0	0	0
Charleston	9/5–9/7/68				0	0	0	0
Charleston	3/3/69				0 (total)		0 (total)	
Columbia	3/5–3/18/68				0	0	2	0
Florence	8/6/68				0	0	5	0
Georgetown	2/20/68				0	0	3	0
Spartanburg	11/13/68				0	0	3	0
Tenn: Alcoa	4/68				0	0	3	0
Clarksville	9/13/67	0		0				
Johnson City (Springs)	5/27/68				0	0	0	0
Johnson City (Finished water)	5/27/68				0	0	0	0
Johnson City (Gray Station wells)	5/27/68				0	0	0	0
Kingsport	10 3–10/16/67	0		0				
Knoxville	4/9–4/22/68				0	0	0	0
Nashville	1/1–1/15/69				0	0	0	0
Tex: Amarillo	11/14/68				0 (total)		6 (total)	
Amarillo	11/14/68				0 (total)		9 (total)	
Dallas	5/30/68				0 (total)		0 (total)	
Lubbock	6/5/68				0 (total)		7 (total)	
Lubbock	11/12/68				3 (total)		15 (total)	
Lubbock	11/13/68				0 (total)		3 (total)	
Midland	6/16/68				0 (total)		8 (total)	
Texarkana	5/12/68				0 (total)		5 (total)	
Witchita Falls	6/8/68		0					
Vt: Burlington	7/8–7/22/69				0 (total)		4 (total)	
Va: Norfolk (Moore's Bridge purification plant)	10/28–11/12/68				0	0	5	0
Norfolk (37th St. purification plant)	10/29–11/13/68				0	0	6	0
Portsmouth	11/5–11/19/68				0	0	4	0
W. Va: Charleston	3/19–4/1/69				0 (total)		0 (total)	
Wisc: La Crosse	5/12–5/25/67				0	0	0	0
Milwaukee	8/5–8/19/68				0	0	0	0
New Lisbon	5/12–5/28/67				0	0	0	0
Superior	5/17–5/31/67				0	0	4	0

[a] The minimum detectable radioactivity is 2 pCi/liter for strontium-90, alpha, and beta radioactivity; 0.1 pCi/liter for radium-226; and 1.0 pCi/liter for total radium. All values equal to or less than the minimum detectable radioactivity are reported as zero.

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Table 2. Interstate carrier drinking water analysis program, 1967–1969 summary

Radioactivity	Number of samples	Concentration[a] (pCi/liter)	
		Average	Range
Total radium	19	1.2	0– 7.2
Radium-226	11	2.3	0–11.9
Strontium-90	34	.1	0– 3
Gross alpha:			
Dissolved	129	.4	0–38
Suspended	129	0	
Total sample	64	.8	0–11
Gross beta:			
Dissolved	129	3.7	0–53
Suspended	129	.1	0– 7
Total sample	64	4.0	0–23

[a] The minimum detectable radioactivity is 2 pCi/liter for strontium-90, alpha, and beta radioactivity; 0.1 pCi/liter for radium-226; and 1.0 pCi/liter for total radium. All values equal to or less than the minimum detectable radioactivity are reported as zero.

REFERENCES

(*1*) DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE. Federal Register Rules and Regulations, Title 42, Public Health Chapter 1, Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards: 2154–2155 (March 6, 1962).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Other coverage in *Radiological Health Data and Reports*:

Period	Issue
1961–1966	August 1968

Tritium in Community Water Supplies, 1969

Bureau of Radiological Health
U.S. Public Health Service

During 1969, a comprehensive survey of the quality of community water supplies in selected areas of the United States was conducted by the Bureau of Water Hygiene. Some of the water samples collected were sent to Bureau of Radiological Health laboratories for analysis of the radioactivity content, including tritium. Table 1 gives the results of tritium analyses as performed by the Northeastern, Southeastern, and Southwestern Radiological Health Laboratories.

The samples were collected by the grab sampling method on the date shown except where a range of dates indicates a composite of samples collected over that period of time. Due to the varying sensitivity of procedures used by the three laboratories, the minimum detectable concentration varies. Analytical values which are not statistically significant at the 2-sigma confidence level are reported as less than ($<$) a value corresponding to the approximate limit of detectability.

The significance of the concentrations of tritium observed in community water supplies may be evaluated using a relationship derived by Moghissi and Porter (*1*) from recommendations of the International Commission on Radiological Units and Measurements. This relationship says that a dose equivalent of 0.17 mrem/a results from a tritium concentration in the body of 1 nCi/liter of water. Assuming that the concentration of tritium in all water taken into the body is equal to that found in the water supply, and that the specific activity of tritium in the body is essentially the same as that in the water supply, the radiation dose to the public may be estimated.

The highest concentration of tritium observed in the water supplies analyzed was 2.7 nCi/liter, corresponding to a dose of 0.47 mrem/a, or less than 0.3 percent of the Federal Radiation Council Radiation Protection Guide (RPG) of 170 mrem/a. The majority of water supplies analyzed had less than 1 nCi/liter of tritium, corresponding to a dose of less than 0.17 mrem/a or less than 0.1 percent of the RPG.

REFERENCE

(*1*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337–339 (1968).

Table 1. Tritium in community water supplies, 1969

Location	Date collected (1969)	Sampled from	Type water	Source	Tritium concentration (nCi/liter)
Calif:					
Adelanto	3/19	Other	Finished	Ground	<0.4
Apple Valley	3/26	Well	Raw	Ground	< .4
Apple Valley	3/26	Well	Raw	Ground	< .4
Apple Valley	3/19	Well	Raw	Ground	< .4
Apple Valley	3/24	Well	Raw	Ground	< .4
Blythe	3/28	Well	Raw	Ground	< .4
Blythe	3/28	Well	Raw	Ground	< .4
Chino	3/20–4/3	Reservoir	Finished	Ground	< .4
Chino	3/27	Well	Finished	Ground	< .4
Claremont	3/20	Well	Raw	Ground	< .4
Colton	3/17	Dist. system	Finished	Other	< .4
Colton	3/20	Dist. system	Finished	Ground	< .4
Colton	3/18	Well	Finished	Ground	< .4
Colton	3/28	Well	Finished	Ground	< .4
East Highlands	3/17	Well	Raw	Ground	< .4
Hesperia	3/24	Well	Finished	Ground	< .4
Highland	3/19	Treatment plant	Finished	Ground	< .4
La Sierra	3/27	Well	Finished	Ground	< .4
La Sierra	3/27	Well	Finished	Ground	< .4
La Sierra	3/27	Well	Finished	Ground	< .4
Loma Linda	3/18–3/25	Dist. system	Finished	Ground	< .4
Lucerne Valley	3/24	Dist. system	Finished	Ground	< .4
Lucerne Valley	3/25	Well	Finished	Ground	< .4
Needles	3/21	Well	Raw	Ground	[a]1.4± .4
Parker Dam	3/24	Well	Raw	Ground	1.5± .4
Rialto	3/28	Well	Raw	Ground	< .4
San Bernardino	3/28	Dist. system	Finished	Ground	< .4
San Bernardino	3/19	Well	Finished	Ground	< .4
San Bernardino	3/17	Well	Raw	Ground	< .4
San Bernardino	3/19	Reservoir	Finished	Ground	< .4
Victorville	3/27	Well	Raw	Ground	< .4
Victorville	3/27	Well	Raw	Ground	< .4
Colo:					
Beulah	6/17	Treatment plant	Finished	Surface	1.1± .2
Pueblo	6/13–6/26	Treatment plant	Finished	Surface	2.0± .2
Pueblo	6/18	Well	Finished	Ground	< .4
Conn:					
Greenwich	6/4–6/19	Treatment plant	Finished	Surface	1.4± .7
Ga:					
Senoia[b]	7/9	Well	Raw	Ground	< .2
Taylorsville[b]	7/16	Well	Raw	Ground	< .2
Sale City[b]	8/4	Well	Raw	Ground	< .2
Cartersville[b]	8/5	Well	Raw	Ground	< .2
Ind:					
Lawrenceburg	3/5–3/18	Treatment plant	Finished	Ground	1.4± .8
Kans:					
Gardner	6/4–6/18	Treatment plant	Finished	Surface	< .4
Olathe	6/11–6/24	Treatment plant	Finished	Ground	< .4
Olathe	6/17	Treatment plant	Finished	Surface	.4± .4
Spring Hill	6/4–6/17	Treatment plant	Finished	Surface	.7± .4
La:					
Gretna	6/16–6/29	Treatment plant	Finished	Surface	.4± .1
New Orleans	6/20	Reservoir	Finished	Ground	< .2
Chalmette	6/19–7/2	Treatment plant	Finished	Surface	.3± .2
Westwego	6/17–6/30	Treatment plant	Finished	Surface	.5± .2
Mo:					
Cleveland	6/5–6/18	Treatment plant	Finished	Surface	< .4
Harrisonville	6/5–6/19	Treatment plant	Finished	Surface	.4± .4
Kansas City	6/12–6/25	Treatment plant	Finished	Surface	1.2± .4
Pleasant Hill	6/6–6/20	Treatment plant	Finished	Surface	.9± .4
Raymore	6/5–6/19	Treatment plant	Finished	Surface	.6± .4
Smithville	6/13–6/26	Treatment plant	Finished	Surface	< .4
N.Y:					
Bethpage	7/14–7/28/69	Treatment plant	Finished	Ground	<1.0
Blauvelt	5/2/69	Well	Raw	Ground	<1.0
Brentwood	8/4/69	Well	Raw	Ground	<1.0
Calverton	8/22/69	Well	Finished	Ground	<1.0
Camp Ramaquois (Pomona)	7/10/69	Well	Raw	Ground	.9± .7
Cove Neck	8/1/69	Well	Raw	Ground	<1.0
Garnerville	5/5/69	Well	Finished	Ground	<1.0
Goldens Bridge	5/28/69	Well	Finished	Ground	<1.0
Huntington	8/18/69	Dist. system	Raw	Ground	<1.0
Jamaica	9/10/69	Treatment plant	Partly treated	Ground	<1.0
Jericho	7/14/69	Well	Raw	Ground	<1.0
Levittown	7/15/69	Treatment plant	Finished	Ground	<1.0
Manhasset	7/16/69	Dist. system	Finished	Ground	<1.0
Massapequa	7/29/69	Dist. system	Finished	Ground	<1.0
Massapequa	7/29/69	Dist. system	Finished	Ground	<1.0
Merrick	7/30/69	Well	Raw	Ground	<1.0
Mineola Village	7/31/69	Well	Raw	Ground	.8± .6
Montauk	8/28/69	Well	Raw	Ground	<1.0

See footnote at end of table.

Table 1. Tritium in community water supplies, 1969—Continued

Location	Date Collected (1969)	Sampled from	Type water	Source	Tritium concentration (nCi/liter)
N.Y: (continued)					
Ocean Bay Park	8/26/69	Treatment plant	Finished	Ground	<1.0
Ocean Beach	8/28/69	Well	Other	Ground	<1.0
Port Jefferson	8/6/69	Treatment plant	Finished	Ground	.7± .6
Sea Cliff	7/15/69	Well	Raw	Ground	<1.0
Seaview	8/25/69	Treatment plant	Finished	Ground	<1.0
Shenorock	5/26/69	Treatment plant	Finished	Combined	<1.0
Sloatsburg	4/30/69	Dist. system	Finished	Surface	<1.0
Sparkill	5/6/69	Dist. system	Finished	Ground	<1.0
Spring Valley	5/15/69	Well	Other	Ground	<1.0
Spring Valley	5/2/69	Dist. system	Finished	Combined	<1.0
Wading River	8/7/69	Well	Raw	Ground	.7± .6
Westbury	7/14/69	Treatment plant	Finished	Ground	<1.0
Williston Park	8/1/69	Well	Raw	Ground	.7± .6
Ohio:					
Addyston	2/28	Dist. system	Finished	Ground	<1.0
Lebanon	2/28–3/17	Treatment plant	Finished	Ground	<1.0
Norwood	2/27–3/13	Dist. system	Finished	Ground	<1.0
Waynesville	3/3–3/17	Well	Finished	Ground	1.1± .8
S.C:					
Goose Creek	3/6	Dist. system	Finished	Ground	< .2
Edisto Beach	3/4	Dist. system	Other	Ground	< .2
Edisto Beach	3/4	Well	Other	Ground	< .2
Isle of Palms	3/4	Dist. system	Finished	Ground	.3± .1
Johns Island	3/5	Well	Other	Ground	< .2
Vt:					
Ascutney	9/2	Dist. system	Partly treated	Combined	<1.0
Bellow Falls	7/15	Dist. system	Finished	Surface	<1.0
Bennington	7/15–7/28	Reservoir	Finished	Combined	<1.0
Cambridge	7/23	Dist. system	Finished	Ground	1.2± .9
Canaan	7/23	Dist. system	Raw	Ground	2.1± .9
Concord	7/30	Dist. system	Raw	Ground	1.5± .6
Derby Center	7/16	Treatment plant	Finished	Surface	<1.0
East Calais	8/29	Dist. system	Finished	Ground	<1.0
East Fairfield	8/21	Well	Raw	Ground	2.7± .6
East Haven	7/31	Dist. system	Finished	Ground	<1.0
Lake Elmore	8/21	Reservoir	Raw	Ground	2.1± .6
Enosburg Falls	7/24	Dist. system	Finished	Ground	1.3± .9
Essex Junction	8/8–8/21	Treatment plant	Finished	Surface	.8± .5
Fair Haven	7/9	Other	Raw	Surface	2.1± .7
Fairlee	7/10	Treatment plant	Finished	Surface	1.6± .7
Guildhall	8/1	Dist. system	Finished	Surface	1.9± .6
Hardwick	7/16	Dist. system	Finished	Ground	<1.0
Huntington Center	7/14	Other	Raw	Surface	1.5± .9
Lunenburg	7/28	Dist. system	Finished	Ground	1.8± .9
Lyndonville	8/6	Dist. system	Finished	Surface	1.8± .6
Manchester Center	7/15	Dist. system	Finished	Surface	1.4± .9
Mendon	9/17	Dist. system	Other	Ground	<1.0
Newport	9/18	Other	Partly treated	Surface	<1.0
Northfield	7/17	Well	Finished	Ground	1.5± .7
North Montpelier	8/18	Dist. system	Raw	Ground	2.1± .6
North Pownal	7/17	Dist. system	Finished	Surface	1.3± .8
Pittsford	7/30	Dist. system	Other	Ground	1.6± .6
Poultney	7/9	Other	Raw	Combined	1.5± .7
Putney	7/29	Dist. system	Finished	Ground	<1.0
Randolph Center	8/20	Dist. system	Finished	Ground	1.7± .6
Readsboro	8/5	Dist. system	Raw	Surface	1.4± .6
St. Johnsbury Center	7/10	Treatment plant	Finished	Surface	<1.0
St. Johnsbury Center	8/6	Dist. system	Finished	Ground	1.3± .6
Sheldon	7/24	Dist. system	Finished	Ground	1.2± .7
South Barre	8/19	Dist. system	Finished	Ground	1.7± .6
South Royalton	8/25	Reservoir	Raw	Ground	<1.0
Sutton	8/6	Other	Raw	Ground	1.3± .6
Thetford	8/21	Other	Finished	Ground	<1.0
Waterbury	8/28	Dist. system	Finished	Ground	<1.0
Waterbury Center	8/18	Dist. system	Finished	Ground	2.0± .6
Winooski	8/4	Dist. system	Finished	Ground	<1.0
W. Va:					
Corton	3/18	Treatment plant	Finished	Surface	.2± .1
Decota	3/26–4/8	Treatment plant	Finished	Ground	< .2
Nitro	3/21–4/3	Treatment plant	Finished	Surface	.2± .1
Pinch	3/3–3/18	Treatment plant	Finished	Surface	.5± .1
Republic	3/24	Dist. system	Finished	Ground	.4± .1
Sharon	3/20–4/3	Treatment plant	Finished	Ground	.2± .1
Sissonville	3/17–3/31	Treatment plant	Finished	Surface	.6± .1

[a] Two-sigma error.
[b] These samples were not part of this study, but were collected in a related survey on rural water.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	April–December 1969	October 1970

XUM

1. Radiation Alert Network August 1970

National Air Pollution Control Administration
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate National Air Pollution Control Administration officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality And Emission Data, NAPCA, Cincinnati, Ohio. A detailed description of the sampling and analytical proceddures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during August 1970. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

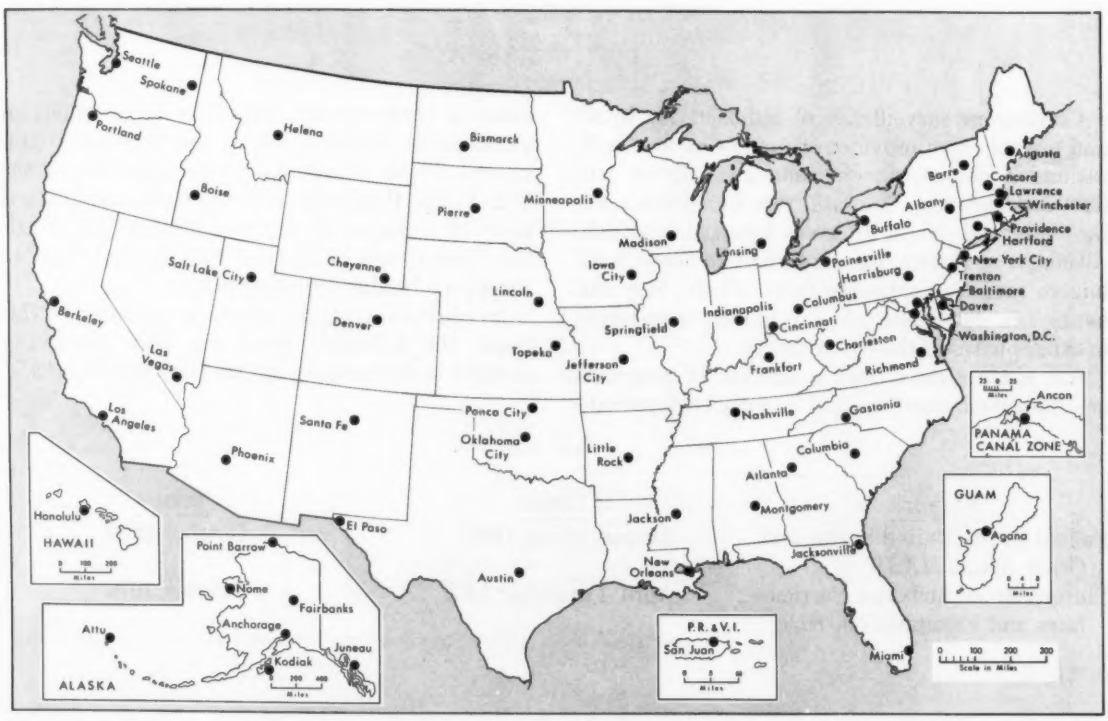

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, August 1970

Station location		Air surveillance					Precipitation			
		Gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Total depth samples (mm)	Field estimation of deposition		
	Number of samples	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala: Montgomery	21	3	0	1	Oct 70	6	152	6	152	40
Alaska: Anchorage	13	0	0	0	June 70	[c]				
Attu Island	30	0	0	0	Nov 70	[c]				
Fairbanks	18	1	0	1	July 70	8	50	8	50	28
Juneau	7	8	0	4	Aug 70	6	162	6	162	0
Kodiak	[b]				Sept 70	[c]				
Nome	[b]				Dec 70	[c]				
Point Barrow	[b]				Dec 70	[c]				
Ariz: Phoenix	11	4	1	2	Aug 70	[c]				
Ark: Little Rock	12	4	0	1	June 70	[c]				
Calif: Berkeley	21	0	0	0	Sept 70	[c]				
Los Angeles	21	3	0	1	Mar 70	[c]				
C.Z: Ancon	17	0	0	0	Sept 70	[c]				
Colo: Denver	20	7	1	4	Sept 70	3	10	[d]		
Conn: Hartford	21	2	0	1	July 70	6	69	6	69	9
Del: Dover	20	2	0	1	May 70	[c]				
D.C: Washington	25	1	0	0	Dec 70	[c]				
Fla: Jacksonville	21	1	0	0	June 70	11	323	5	125	40
Miami	13	0	0	0	July 70	6	105	6	105	0
Ga: Atlanta	20	2	1	1	Apr 70	1	31	1	31	15
Guam: Agana	[b]				May 70	[c]				
Hawaii: Honolulu	25	0	0	0	Nov 70	2	10	[d]		
Idaho: Boise	21	4	1	2	Nov 70	[c]				
Ill: Springfield	12	2	0	1	Dec 70	[c]				
Ind: Indianapolis	[b]				Apr 70	[c]				
Iowa: Iowa City	15	5	1	2	Sept 70	4	59	4	59	1
Kans: Topeka	21	8	1	3	June 70	5	39	5	39	1
Ky: Frankfort	10	5	2	2	Dec 70	[c]				
La: New Orleans	18	1	0	0	Aug 70	9	316	[d]		
Maine: Augusta	20	3	0	2	Feb 70	3	63	3	63	0
Md: Baltimore	21	2	0	1	Aug 70	6	39	6	39	1
Mass: Lawrence	21	2	0	1	Sept 70	6	99	6	99	0
Winchester	20	3	0	1	Oct 70	6	104	6	104	0
Mich: Lansing	19	5	0	2	Nov 70	4	59	4	59	9
Minn: Minneapolis	21	3	0	2	May 70	5	80	4	65	4
Miss: Jackson	14	2	0	1	Aug 70	4	108	4	108	19
Mo: Jefferson City	20	8	1	2	Apr 70	6	77	6	77	0
Mont: Helena	17	3	0	1	Oct 70	2	18	2	18	0
Nebr: Lincoln	14	7	1	4	Apr 70	2	21	2	21	3
Nev: Las Vegas	18	3	1	2	July 70	[c]				
N.H: Concord	[b]				Dec 70	[c]				
N.J: Trenton	21	2	0	1	Aug 70	5	110	5	110	4
N. Mex: Santa Fe	21	2	1	1	Oct 70	8	52	8	52	0
N.Y: Albany	13	2	0	1	Apr 70	6	63	6	63	23
Buffalo	21	2	0	1	Sept 70	[c]				
New York City	[b]				Oct 70	[c]				
N.C: Gastonia	16	9	1	4	Sept 70	5	99	[d]		
N. Dak: Bismarck	21	5	0	2	Dec 70	2	4	2	4	1
Ohio: Cincinnati	[b]				May 70	[c]				
Columbus	4	3	1	2	Aug 70	[c]				
Painesville	20	5	1	3	July 70	4	51	4	51	9
Okla: Oklahoma City	21	6	1	3	Nov 70	2	17	1	11	1
Ponca City	21	5	1	3	July 70	5	40	5	40	0
Oreg: Portland	18	2	0	1	Apr 70	[c]				
Pa: Harrisburg	14	3	0	1	Apr 70	3	46	3	46	10
P.R: San Juan	[b]				Aug 70	[c]				
R.I: Providence	19	2	0	1	Nov 70	1	10	1	10	2
S.C: Columbia	14	1	0	1	Oct 70	3	49	2	10	0
S. Dak: Pierre	8	6	1	3	Aug 70	[c]				
Tenn: Nashville	20	2	0	1	Nov 70	6	104	6	104	3
Tex: Austin	13	11	2	4	May 70	[c]				
El Paso	[b]				Dec 70	[c]				
Utah: Salt Lake City	31	3	1	1	Mar 70	1	7	1	7	0
Vt: Barre	19	6	0	3	June 70	6	71	6	71	11
Va: Richmond	21	2	0	1	June 70	3	64	3	64	26
Wash: Seattle	21	1	0	0	June 70	2	16	[d]		
Spokane	21	3	1	2	May 70	[c]				
W. Va: Charleston	21	3	0	2	Oct 70	8	90	8	90	17
Wisc: Madison	21	3	0	2	June 70	3	9	3	9	2
Wyo: Cheyenne	21	7	1	3	July 70	[c]				
Network summary	1,099	11	0	2		104	83	4	62	8

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

XUM

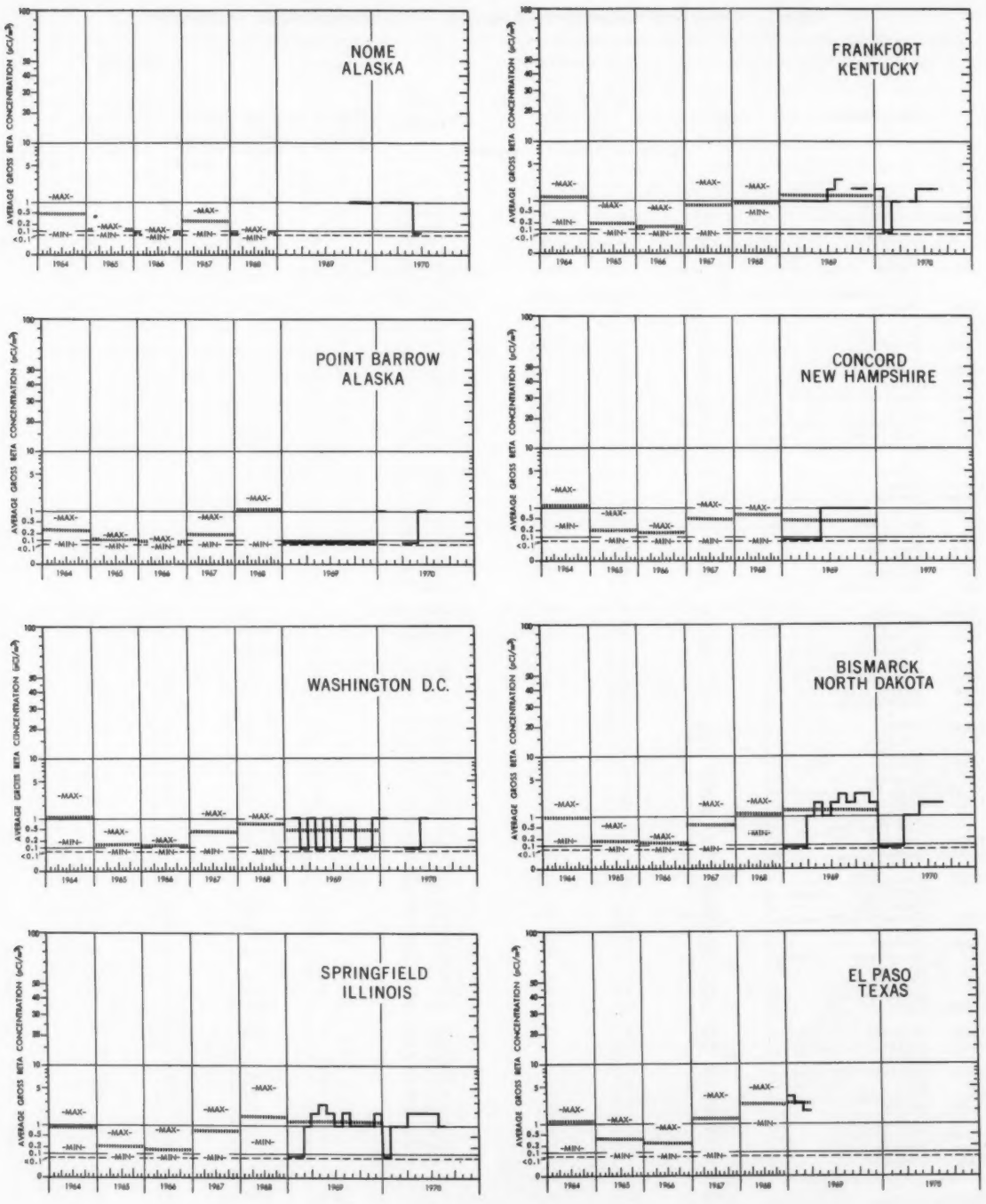

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1964–August 1970

2. Canadian Air and Precipitation Monitoring Program,[1] August 1970

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for August 1970 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, August 1970

Station	Number of samples	Air surveillance, gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m³)
Calgary	0	NS	NS	NS	387	2.6
Coral Harbour	25	0.5	0.0	0.2	122	9.8
Edmonton	30	.5	.0	.2	121	6.0
Ft. Churchill	11	.3	.0	.1	106	7.0
Fredericton	5	.3	.1	.2	NS	NS
Goose Bay	5	.2	.1	.2	49	5.3
Halifax	5	.2	.1	.2	55	6.1
Inuvik	5	.1	.0	.1	65	3.8
Montreal	30	.5	.0	.3	38	3.9
Moosonee	5	.6	.0	.2	42	3.3
Ottawa	31	.6	.1	.3	18	1.3
Quebec	25	.5	.1	.3	84	8.8
Regina	5	.3	.1	.2	177	3.2
Resolute	5	.1	.0	.1	31	1.0
St. John's, Nfld.	5	.2	.1	.1	24	7.9
Saskatoon	5	.3	.1	.2	180	4.8
Sault Ste. Marie	5	.4	.2	.2	83	4.5
Thunder Bay	31	.6	.1	.3	96	5.9
Toronto	31	.7	.1	.3	84	8.1
Vancouver	5	.2	.1	.1	248	1.4
Whitehorse	31	.3	.0	.1	NS	NS
Windsor	31	.6	.1	.3	49	1.0
Winnipeg	3	.2	.1	.1	74	5.5
Yellowknife	31	.4	.0	.1	25	2.2
Network summary..	365	0.7	0.0	0.2	98	4.2

NS, no sample.

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program August 1970

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The August 1970 air monitoring results from the participating countries are given in table 3.

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, August 1970

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	12	0.25	0	0.08
Bolivia:	La Paz	21	8.33	.17	3.06
Chile:	Santiago	24	2.27	.09	.51
Colombia:	Bogota	19	.28	.02	.11
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	16	2.48	.03	.71
	Quito	NS	NS	NS	NS
Guyana	Georgetown	6	.42	.05	.19
Jamaica:	Kingston	NS	NS	NS	NS
Peru:	Lima	26	7.71	.49	1.73
Venezuela:	Caracas	13	.21	.05	.12
West Indies:	Trinidad	NS	NS	NS	NS
Pan American summary		137	8.33	0	1.01

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Reported values of less than 0.005 pCi/m³ are considered as 0.00 pCi/m³ in averaging.
NS, no sample.

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(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for Mound Laboratory, Savannah River Plant, and S1C Prototype Reactor Facility.

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Mound Laboratory[2] July–December 1969

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

[2] Summarized from "Environmental Monitoring Report: July–December 1969 and 1969 Summary" (MLM-1616).

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters, was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected on filter paper with a high-volume air sampler. One-fourth of each filter paper is processed and analyzed for polonium. The remaining three-fourths of each filter paper is processed and analyzed for plutonium.

Airborne tritium is monitored by bubbling air through a liquid scintillation counting solution with p-dioxane as the organic solvent. The counting solution is counted directly in a liquid spectrometer.

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The results of the airborne monitoring program are presented in tables 1, 2, and 3. The average concentrations of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 1. Atmospheric monitoring of polonium-210 Mound Laboratory environs, July–December 1969

Range (miles)	Number of samples	Concentration[a] (fCi/m³)		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	13	23.8	14.5	0.07
0–3 (downwind)	14	15.6	8.7	.04
3–5 (downwind)	14	35.8	14.6	.07
5–10 (downwind)	14	64.9	17.8	.09
10–15 (downwind)	14	28.0	12.0	.06
15–20 (downwind)	13	14.4	6.8	.03

[a] Lowest detectable level (LDL) for polonium-210 in air is 8.0 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 2. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, July–December 1969

Range (miles)	Number of samples	Concentration[a] (fCi/m³)		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	13	12.7	6.1	0.61
0–3 (downwind)	14	19.3	6.2	.62
3–5 (downwind)	14	15.2	8.0	.80
5–10 (downwind)	14	16.0	9.1	.91
10–15 (downwind)	14	19.7	7.5	.75
15–20 (downwind)	13	12.2	5.5	.55

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 1 pCi/m³.

Table 3. Atmospheric monitoring of tritium, Mound Laboratory environs, July–December 1969

Range (miles)	Number of samples	Concentration[a] (nCi/m³)		Average as percent of AEC standards[b]
		Maximum	Average	
0–3 (upwind)	12	5.48	1.51	0.75
0–3 (downwind)	12	1.00	1.00	.50
3–5 (downwind)	12	3.99	1.25	.62
5–10 (downwind)	11	2.39	1.13	.56
10–15 (downwind)	11	1.51	1.06	.53
15–20 (downwind)	11	1.51	1.06	.53

[a] Lowest detectable limit for tritium in air is 1.00 nCi/m³. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3 being purified at the Mound Laboratory contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and discharged to the same drainage ditch as plutonium waste. Some tritium-

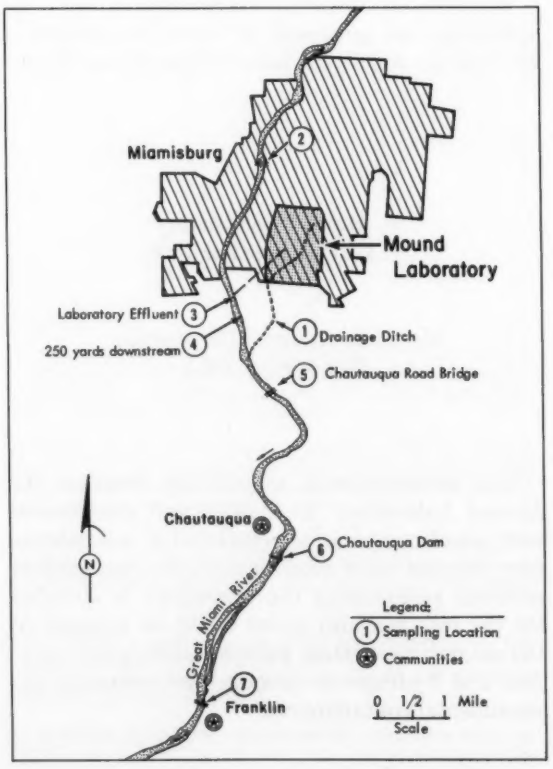

Figure 1. Water sampling locations, Mound Laboratory

Table 4. Offsite water monitoring for radioactivity, Mound Laboratory environs, July–December 1969

Radionuclide and sampling locations[a]	Number of samples	Concentration	
		Maximum	Average[b]
Polonium-210:[c] (pCi/liter)			
1 (Drainage ditch)	23	2.70	1.84
2 (Upstream from laboratory)	23	1.80	1.80
3 (Laboratory effluent)	22	768	114
4 (250-yards downstream)	22	57.7	6.84
5 (Chautauqua Road Bridge)	22	1.80	1.80
6 (Chautauqua Dam)	21	1.80	1.80
7 (Franklin, Ohio)	21	1.80	1.80
8 (Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	1.80	1.80
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	23	1.80	1.80
Plutonium-238:[c] (pCi/liter)			
1 (Drainage ditch)	23	40.6	12.3
2 (Upstream from laboratory)	23	11.3	5.32
3 (Laboratory effluent)	22	314	28.9
4 (250-yards downstream)	22	8.71	5.38
5 (Chautauqua Road Bridge)	22	11.3	5.73
6 (Chautauqua Dam)	21	10.4	5.39
7 (Franklin, Ohio)	21	10.2	5.09
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	23	7.06	4.81
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	24	95.7	9.14
Tritium (hydrogen-3):[c] (μCi/liter)			
1 (Drainage ditch)	22	14.7	1.11
2 (Upstream from Laboratory)	22	.17	.06
3 (Laboratory effluent)	21	.62	.19
4 (250-yards downstream)	21	.40	.07
5 (Chautauqua Road Bridge)	21	.34	.07
6 (Chautaugua Dam)	20	.46	.07
7 (Franklin, Ohio)	20	.42	.07
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory)	22	.43	.07
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory)	22	.39	.07

[a] See figure 1 for number of sampling locations.
[b] The applicable AEC radiation protection standards for uncontrolled areas are as follows:
Polonium-210 in water: 700 pCi/liter
Plutonium-238 in water: 5 nCi/liter
Tritium in water: 3 μCi/liter
[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.
Minimum detectable level for plutonium-238 in water is 4.5 pCi/liter.
Minimum detectable level for tritium in water is 50 nCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Water samples are collected weekly from the Great Miami River, the drainage ditch, and two ponds northeast of Mound Laboratory (figure 1). The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 4 for July–December 1969.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1969	December 1969
January–June 1969	June 1970

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2. Savannah River Plant[3] July–December 1969

E. I. duPont de Nemours
Aiken, S.C.

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200 square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina, and Richmond, Burke, and Screven Counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the AEC radiation protection standards as given in the AEC Manual.

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about a 25-mile radius from the center of the plant (figure 2). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S.C., are so distant from SRP that the effect of SRP operations is negligible; they serve as reference points for determining background radioactivity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between fallout and SRP releases.

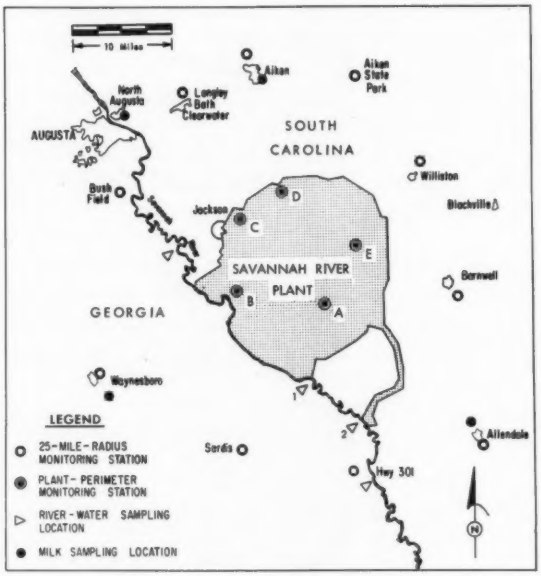

Figure 2. Environmental sampling locations Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separation areas, was obscured by fallout. The influence of nuclear tests, which resumed in September 1961, is shown in figure 4. The present low levels of atmospheric activity are attributed to the moratorium on above-ground nuclear tests.

[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, July–December 1969 (DPST-10-30-1).

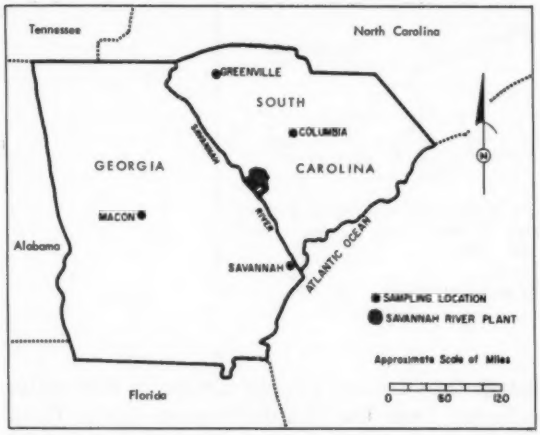

Figure 3. Distant air monitoring stations Savannah River Plant

The observed spring increases are anticipated and result primarily from the mixing of the stratospheric debris into the troposphere. The average beta concentration in air (0.15 pCi/m³) was about the same as the previous 6 months and was two-fold higher than the same period of 1968. Gamma-emitting radionuclides in fallout were cesium-134-137, cerium-141-144, ruthenium-103-106, and zirconium-niobium-95.

Short radioactive half-life barium-lanthanum-140, neptunium-239, and iodine-131 in routine air samples were less than the level of detection throughout the period. The major component, beryllium-7, is a naturally occurring radionuclide formed by interaction of cosmic rays with oxygen and nitrogen in the upper atmosphere. Radioactivity in air, determined from filter analyses, is shown in table 5. The July-December 1969 concentrations of filterable beta radioactivity (0.15 pCi/m³) and alpha radioactivity (0.7 fCi/m³) in air were 0.15 and 1.0 percent of the respective AEC standards. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.2 percent of the AEC standard.

Deposition of fallout during July–December 1969 averaged 7 nCi/m² at the plant perimeter locations and 8 nCi/m² at 25-mile radius locations; comparable values for the last half of 1969 were

Table 5. Radioactivity in air, Savannah River Plant, July–December 1969

Sampling points	Alpha radioactivity[a] (fCi/m³)			Nonvolatile beta radioactivity[b] (pCi/m³)			Specific radionuclides in composite samples (pCi/m³)					
	Maximum	Minimum	Average	Maximum	Minimum	Average	$^{89,90}Sr$	^{137}Cs	$^{141,144}Ce$	$^{103,106}Ru$	^{95}Zr-Nb	^{7}Be[c]
Plant perimeter:												
A	1.8	ND	0.6	0.49	0.06	0.17						
B	1.3	.4	.7	.52	.06	.21						
C	1.4	ND	.6	.35	.06	.16	0.009	0.01	0.04	0.06	0.08	0.14
D	1.1	ND	.6	.34	.06	.15						
E	1.1	ND	.5	.33	.06	.15						
Average			0.6			0.17						
25-mile-radius:												
Aiken Airport	1.6	ND	.6	.33	ND	.14						
Aiken State Park	1.1	ND	.6	.33	.05	.14						
Allendale	.9	ND	.5	.36	.04	.14						
Barnwell	1.1	ND	.6	.39	.06	.14						
Bush Field	.8	.3	.5	.32	.02	.12	.009	.01	.04	.04	.08	.14
Langley	4.9	.4	1.0	.32	.05	.14						
Sardis	1.1	ND	.5	.36	.04	.14						
Waynesboro	1.3	.3	.6	.31	.06	.14						
Williston	2.8	ND	1.1	.40	.04	.14						
Highway 301	2.3	ND	.6	.39	.06	.17						
Average			0.7			0.14						
Distant air-monitoring:												
S.C: Columbia	2.3	ND	1.0	.51	ND	.15						
Greenville	1.7	.3	.9	.41	.06	.17						
Ga: Macon	1.4	ND	.7	.35	.04	.13	.008	.01	.04	.04	.08	.13
Savannah	1.4	ND	.6	.29	.06	.16						
Average			0.8			0.15						

[a] AEC radiation protection standard—70 fCi/m³.
[b] AEC radiation protection standard—100 pCi/m³.
[c] The beryllium-7 concentrations reported for the January–June 1969 were incorrect. The corrected concentration range is 0.11–0.15 pCi/m³.

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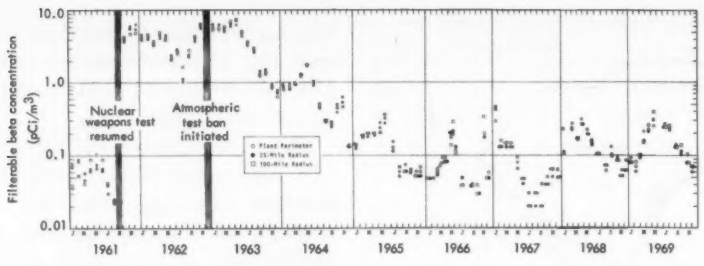

Figure 4. Influence of weapons tests

22 and 21 nCi/m² (excluding naturally occurring beryllium-7). Deposition at each sampling location is presented in table 6.

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 5). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort County, S.C. Water is supplied through a canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well supply with river water during periods of peak demand. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 2 nCi/liter (0.07 percent of the AEC standard) during the July–December 1969 period. The annual radiation exposure of an individual in this population from the consumption of water containing this low concentration of tritium is 0.33 mrem. This exposure may be compared with 40 mrem/a from natural potassium found in the body of all persons or with the 170 mrem/a specified by the Federal Radiation Council as the annual dose guide for members of the public.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in September. There was no evidence that SRP contributed radioactivity to

Table 6. Total fallout deposited, Savannah River Plant, July–December 1969

Sampling points	Radioactivity (nCi/m²)						
	Alpha[a]	Strontium-89	Strontium-90	Cesium-137	Cerium-141, -144	Zirconium-niobium-95	Beryllium-7[b]
Plant perimeter:							
A	2.4	0.9	0.3	0.8	1.1	2.8	5.7
B	2.0	1.1	.1	1.0	1.7	2.9	9.5
C	4.6	.8	.3	.8	1.7	2.7	10.2
D	2.5	.7	.2	.7	1.8	1.7	10.5
E	4.4	.5	.2	1.2	4.1	4.0	17.3
Average	3.2	.8	.2	.9	2.1	2.8	10.7
25-mile-radius:							
Aiken Airport	1.6	1.5	.3	1.1	3.6	4.1	14.1
Aiken State Park	1.3	1.0	.4	1.0	1.6	2.9	7.6
Allendale	2.3	.6	.3	.8	1.5	2.3	10.5
Barnwell	1.4	.8	.4	.9	3.4	5.4	10.7
Bush Field	.5	3	.3	.9	1.3	1.9	6.9
Langley	2.9	1.1	.4	1.2	3.2	5.2	14.8
Sardis	1.3	.8	.5	1.2	2.2	4.3	14.2
Waynesboro	2.1	.6	.2	.9	1.3	2.8	9.0
Williston	1.6	.9	.3	1.0	2.0	3.7	8.7
Highway 301	3.9	1.0	.3	1.0	3.1	4.4	13.3
Average	1.9	.8	.3	1.0	2.3	3.7	11.0

[a] Multiple by 10^{-2}.
[b] A naturally-occurring radionuclide. The beryllium-7 depositions reported for January–June 1969 are in error. The corrected range is 7.7–11.5 nCi/m².

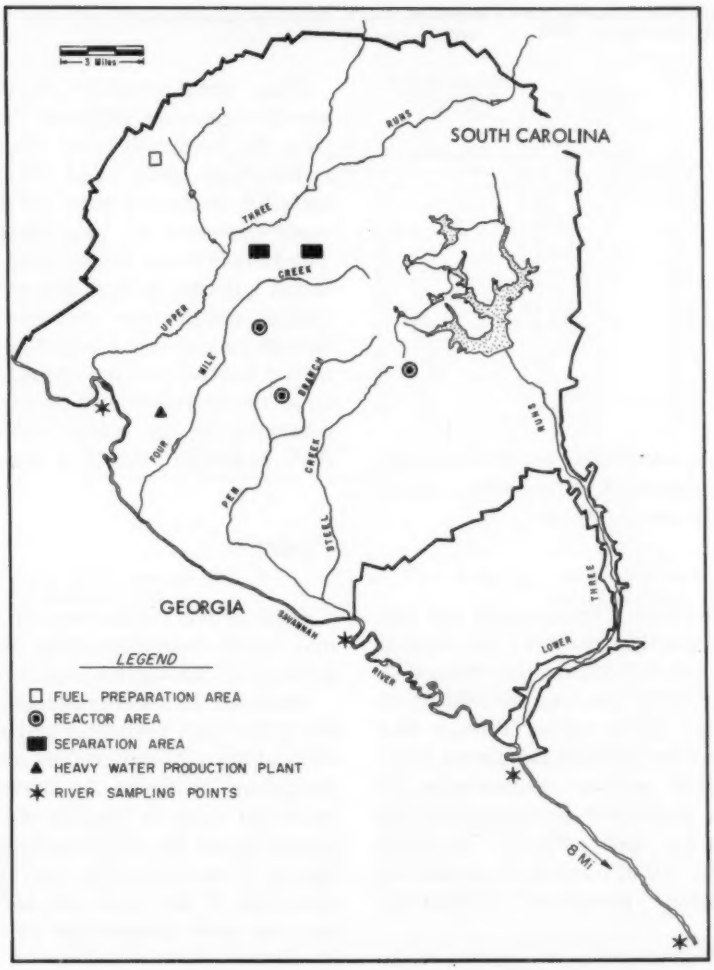

Figure 5. SRP production and effuent streams

drinking water supplies. Concentrations of alpha radioactivity (1.3 pCi/liter) and beta radioactivity (8 pCi/liter) were essentially the same as those observed before plant startup. Radioactivity in public water supplies data is presented in table 7.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Concentrations of alpha and nonvolatile beta radioactivity in river water for the past year are presented in table 8. Average concentrations of specific radionuclides found in river water during July–December 1969 appear in table 9.

Tritium, sulfur-35, and trace amounts of cesium-137, strontium-89, and strontium-90 were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP effluents.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water

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Table 7. Radioactivity in public water supplies, July–December 1969

Sampling points	Alpha radioactivity[a] (pCi/liter)	Nonvolatile beta radioactivity[b] (pCi/liter)
	September	September
Aiken	1.4	4
Allendale	1.6	10
Augusta	ND	9
Barnwell	.4	ND
Bath	2.1	13
Blackville	.6	4
Clearwater	.3	7
Jackson	4.9	16
Langley	2.1	11
New Ellenton	2.5	11
North Augusta	.2	7
Sardis	ND	6
Waynesboro	.2	4
Williston	1.3	5
Average	1.3	8

[a] AEC radiation protection standard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, nondetectable, less than sensitivity of analysis.

moderator in the reactors. Chromium-51 and sulfur-35 (also a beta-particle emitter), the second and third most abundant radionuclides released to the river, are produced by neutron irradiation of stable chromium and stable sulfur. Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The respective concentrations of tritium, chromium-51, and sulfur-35 in river water averaged 0.30, <0.001 and 0.01 percent of the AEC radiation protection standards, respectively.

Fish in Savannah River

Fish, predominantly bream, were collected weekly upstream, adjacent to, and downstream from the Savannah River Plant effluents. Specific radionuclide analyses of fish are summarized in table 10, replacing more generalized data previously reported as "nonvolatile beta activity." The radioactivity in bone and flesh from fish collected adjacent to and downstream from SRP indicates some minor contribution by SRP. Although measurably higher than similar collections at the control station upstream from SRP effluents, the increase is of minor significance when compared to the intake guides defined by the AEC radiation protection standards.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or sorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route (these are not designated on figure 2). Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year. Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis

Table 8. Radioactivity in Savannah River water, July–December 1969

Sampling points	Alpha radioactivity[a] (pCi/liter)				Nonvolatile beta radioactivity[b] (pCi/liter)			
	July–December 1969			January–June 1969	July–December 1969			January–June 1969
	Maximum	Minimum	Average	Average	Maximum	Minimum	Average	Average
1 mile upstream from Upper Three Runs Creek (control)	0.4	ND	ND	ND	10	ND	4	ND
Downstream from Steel Creek	.5	ND	ND	ND	14	ND	6	4
Downstream from Lower Three Runs Creek	.4	ND	ND	ND	23	ND	8	7
8 miles downstream from Lower Three Runs Creek	.2	ND	ND	ND	19	ND	7	5

[a] AEC radiation protectionstandard—10 pCi/liter; sensitivity of analysis—0.2 pCi/liter.
[b] AEC radiation protection standard—3 nCi/liter; sensitivity of analysis—4.0 pCi/liter.
ND, nondetectable, less than sensitivity of analysis.

Table 9. Average concentration of radionuclides in Savannah River water, July–December 1969

Nuclides	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (1 mile upstream from Upper Three Runs Creek)	Highway 301 (8 miles downstream from Lower Three Runs Creek)	Percent AEC standard at Highway 301
Tritium	600	910	9,100	0.30
Ruthenium-103,106	3.2	ND	ND	<.03
Cerium-141,144	2.5	ND	ND	<.02
Cesium-134,137	.6	ND	.8	.004
Neptunium-239	2.2	ND	ND	<.002
Barium-lanthanum-140	1.6	ND	ND	<.01
Zirconium-niobium-95	.5	ND	ND	<.001
Chromium-51	4.3	ND	ND	<.001
Strontium-89	.3	ND	.4	.01
Iodine-131	.2	ND	.3	.10
Strontium-90	.01	.9	1.1	.37
Cobalt-60	1.4	ND	ND	<.005
Zinc-65	1.1	ND	ND	<.001
Manganese-54	.4	ND	ND	<.0004
Sulfur-35	5.0	ND	6.3	.01

ND, nondetectable, less than sensitivity of analysis.

Table 10. Radioactivity in Savannah River fish, July–December 1969

Location	Type of sample[a]	Concentration (pCi/g wet weight)			
		Strontium-89–90[b]		Cesium-137	
		Maximum	Average	Maximum	Average
Above plant boundary (Control)	Bone	14	8	<2	<2
	Flesh	NA	NA	6	1
Adjacent to Plant	Bone	19	14	<2	<2
	Flesh	NA	NA	15	5
Below Plant at Highway 301	Bone	19	15	<2	<2
	Flesh	NA	NA	21	5

[a] Monthly composites of weekly collections for strontium-89–90, and cesium-137.
[b] Previous analyses have indicated a 1:100 strontium ratio between flesh and bone.
NA, no analysis.

Table 11. Radioactivity on vegetation, July–December 1969

Radionuclides[a]	Concentration (pCi/g dry weight)			
	Plant perimeter (7 locations)		25-mile radius (7 locations)	
	Maximum	Average	Maximum	Average
Alpha emitters	0.6	0.1	0.5	0.1
Cesium-137	3.5	1.1	1.3	.7
Cerium-141,144	5.1	4.0	9.6	5.0
Ruthenium-103,106	2.6	ND	3.8	ND
Beryllium-7	7.2	4.7	12.0	7.0
Iodine-131	ND	ND	ND	ND
Barium-lanthanum-140	ND	ND	ND	ND
Zirconium-niobium-95	3.4	2.2	5.8	2.6

[a] Sensitivity of analysis in pCi/g dry weight, alpha emitters 0.10; cesium-137, 0.3; cerium-141,144, 1.0; ruthenium-103,106, 1.4; beryllium-7, 3.0; iodine-131, 0.2; barium-lanthanum-140, 6.0; zirconium-niobium-95, 0.5.
ND, nondetectable, less than sensitivity of analysis.

Gamma-emitting radionuclides in grass samples (excluding beryllium-7) were from fallout. Alpha-particle emitters averaged 0.1 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.2 pCi/g during the first half of 1969; gamma-ray emitters averaged 12.0 and 15.3 pCi/g, respectively, as compared to 17.6 and 22.4 pCi/g for the first half of 1969. Radioactivity in grass samples is presented in table 11. While the exact nature of the alpha radioactivity decrease is not known, the change is commensurate with previously observed changes that appear to be seasonal.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant (figure 2). Samples, collected biweekly, were analyzed for tritium and radioiodine. Strontium-90 and cesium-137 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during July–December 1969 are shown in table 12.

Average concentrations of the radionuclides in milk were 9 pCi/liter of strontium-90 (compared to 11 pCi/liter of strontium-90 during the first half of 1969) and 12 pCi/liter of cesium-137. Io-

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Table 12. Radioactivity in milk from local dairies, Savannah River Plant, July–December 1969

Distributing points	Concentration						
	Tritium[a] (nCi/liter)			Strontium-90[b] (pCi/liter)		Cesium-137[c] (pCi/liter)	
	Maximum	Minimum	Average	September	December	September	December
Aiken	1	ND	ND	10	8	14	ND
North Augusta	4	ND	1.9	10	13	17	ND
Waynesboro	2	ND	1.3	NS	5	NS	10
Major distributors[d]	1	ND	1.0	9	8	10	8

[a] Sensitivity of analysis—3 nCi/liter; AEC standard—3,000 nCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter; AEC standard—300 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter; AEC standard—300 pCi/liter.
[d] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.
NS, no sample.

dine-131 was less than the sensitivity of the analysis (5 pCi/liter) throughout this period. These values are consistent with those reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level (1,300 pCi/liter) was 0.04 percent of the AEC standard for water.

Food

Samples of farm produce, representing four food categories (grain, fruit, poultry, and leafy vegetables), were collected at 14 localities in the six counties surrounding SRP (not shown on maps) during the summer and fall of 1969. Sixty samples were analyzed by gamma spectrometry for cerium-141-144, iodine-131, ruthenium-103-106, cesium-137, zirconium-niobium-95, and manganese-54. Radiochemical analyses were used for strontium-90 and alpha emitters (uranium and plutonium). With the exception of grains, all foods were prepared for analysis in a manner similar to that used to prepare them for eating. Peelings, seeds, and other nonedible parts were removed. Wheat, containing the whole grains only, and oats, containing both grains and husks, were processed unwashed. Results are summarized in table 13. Concentrations in some samples were too low for reliable measurement, and only results above the detection limit of the analyses are included.

SRP contributions to the levels of radioactivity in foods were so low in 1969 as to be indistinguishable from fallout. With the exception of cesium-137 and strontium-90, all radionuclides in food were near or below levels of detection. Strontium-90 and cesium-137 were about the same as in the 1968 samples with respective peak averages again in collards (0.26 pCi/g) and grain (0.07 pCi/g).

Table 13. Radioactivity of agricultural products, Savannah River Plant, 1969

Products	Number of samples	Concentration[a] (pCi/g net weight)									
		Strontium-90		Cerium-141, 144		Zirconium-niobium-95		Cesium-137		Alpha emitters	
		Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Collards	14	0.26	0.43	0.12	0.20	ND	ND	0.05	0.11	0.002	0.008
Plums	14	.04	.14	ND	.23	ND	ND	ND	.04	.002	.011
Oats, rye, wheat	14	.15	.25	.11	.19	.06	.19	.07	.10	.003	.024
Corn	14	.03	.09	ND	ND	ND	ND	.06	.15	ND	.004
Chicken	6	.09	.14	ND	ND	ND	ND	.06	.07	.002	.012

[a] Sensitivity of analysis in pCi/g, wet weight; strontium-90, 0.02; cerium-141, 144, 0.06; zirconium-niobium-95, 0.02; cesium-137, 0.02; alpha emitters, 0.002.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The July–December 1969 data (shown in table 14) are characteristic of measurements observed at individual stations for the past several years.

Table 14. Environmental gamma radiation, Savannah River Plant, July–December 1969

Sampling points	Gamma radiation (mR/24 h)		
	Maximum	Minimum	Average
Plant perimeter:			
A	0.57	0.09	0.24
B	.40	.09	.20
C	.42	.09	.23
D	.43	.07	.16
E	.23	.07	.14
Average			0.19
25-mile-radius:			
Aiken Airport	.26	.07	.16
Aiken State Park	.28	.02	.15
Allendale	.46	.03	.23
Barnwell	.24	.07	.17
Bush Field	.33	.12	.22
Langley	.30	.07	.19
Sardis	.30	.07	.18
Waynesboro	.24	.05	.15
Williston	.38	.19	.19
Highway 301	.46	.09	.31
Average			0.20

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation or was obscured by fallout from offsite sources. Beta radioactivity in air, which showed no relationship with plant operations, was about the same as that observed for January–June 1969 and was a twofold increase over the same period of 1968. Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint. The average concentration of any radionuclide in river water at Highway 301 did not exceed 0.4 percent of the AEC radiation protection standard.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1968	November 1969
January–June 1969	May 1970

3. S1C Prototype Reactor Facility[4] January–December 1969

Combustion Engineering, Inc.
Windsor, Conn.

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. (figure 6). The prototype contains a pressurized water reactor power plant which is primarily used to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

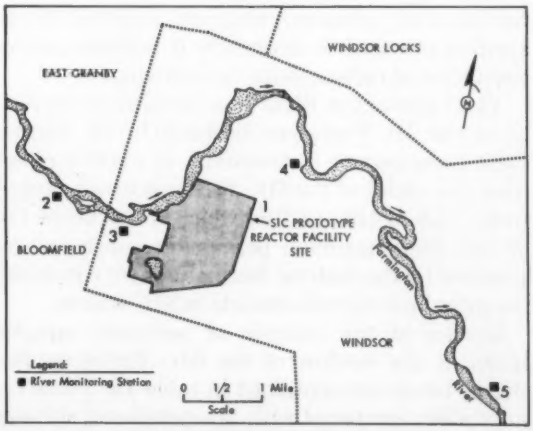

Figure 6. Environmental monitoring locations S1C Prototype site

The low-level radioactive waste discharged intermittently from S1C prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated

[4] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring, Report for 1969."

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and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

Liquid radioactive waste

Drainage from all systems which are known to contain radioactive liquids were collected, processed and sampled prior to discharge to the environment to assure that discharge concentrations were within the required limits. In addition, waste effluent is sampled as it is discharged to the environment. These samples are analyzed for radioactivity, and the results are retained as part of the permanent records.

The S1C Prototype discharged a total of 1.84 megaliters of radioactive liquid waste containing 285.2 microcuries of radioactivity during 1969 for an annual average discharge concentration of 150 pCi/liter.

Water monitoring

Water and sediment samples from the Farmington River are taken quarterly and analyzed. These samples are used to determine if buildup (reconcentration of radioactivity) is occurring.

The Farmington River was sampled at the outlet of the S1C Prototype discharge brook. During 1969, gross gamma radioactivity of water samples from the outlet of the S1C discharge brook ranged from $\leq$5.9 to 410 pCi/liter which is well below the 30 nCi/liter maximum permissible concentration specified by the Federal Regulations for cobalt-60, the most limiting radionuclide in S1C wastes.

Results of the analysis of sediment samples taken at the outflow of the S1C Prototype discharge brook are contained in table 15. These results when compared with preoperational surveys indicate that no significant buildup of radioactivity has occurred.

Table 15. Farmington River sediment sample results, 1969

Period (1969)	Average gross gamma concentration at outlet of discharge brook (pCi/g)
January–March	[a]
April–June	0.36
July–September	1.68
October–December	2.1

[a] Sample not taken because of ice on river.

Airborne radioactivity

All areas onsite where gaseous and/or particulate airborne radioactivity could be present are directed through ducts to monitored stacks. The stacks are monitored for airborne levels on a continuous basis. The facility's operational controls ensure that the radioactive concentration in the environment does not exceed the 100 pCi/m^3 limit. This limit is based on levels of strontium-90 and alpha-particle emitting isotopes being insignificant.

The airborne particulate radioactivity samples taken during discharge are recounted 4 hours after discharge. This delay allows short-lived radioactivity to decay. The air effluent analysis records indicate that no significant airborne radioactivity was discharged above natural backgrounds levels.

Radiation evaluation

Film badges were posted on the site's exclusion area perimeter for the detection of beta-gamma radiation. The badges were processed monthly, and the exposure results were generally less than 10 millirem. The normal background for the surrounding area not influenced by S1C Prototype operation is also 10 millirem per month.

Conclusions

Results of the analyses and of the continuous monitoring throughout 1969 have indicated that S1C Prototype operations have met all of the Federal Regulations pertaining to AEC standards. Environmental analyses indicate that no significant quantities of radioactivity have accumulated above the preoperational environmental results. It is, therefore, concluded that the facility operations have not adversely affected the surrounding environment.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–December 1968	July 1970

Reported Nuclear Detonations, November 1970

(Includes seismic signals from foreign test areas)

On November 4, 1970, the United States recorded seismic signals which presumably originated from the Soviet underground nuclear test area in the Semipalatinsk region. The signals were equivalent to those of nuclear test in the low-intermediate yield range of 20-200 kilotons TNT.

The U.S. Atomic Energy Commission announced only one test for November 1970. A nuclear test of low-intermediate yield (equivalent to 20-200 kilotons TNT) was conducted underground at the Nevada Test Site on November 5, 1970.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

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Figure 1. Nuclear power plants in the United States

SITE	PLANT NAME	CAPACITY (Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,064,500	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant	829,000	Alabama Power Co.	1975
ARKANSAS				
London	Arkansas Nuclear One: Unit 1	850,000	Arkansas Power & Light Co.	1973
London	Arkansas Nuclear One: Unit 2	950,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1975
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1977
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1973
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas & Electric Co.	1974
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1972
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	651,500	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	651,500	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	858,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island: Unit 1	813,000	Florida Power and Light Co.	1973
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1970
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co	1971
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co	1971
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1977
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	545,000	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford: Unit 3	1,140,000	Louisiana Power & Light Co.	1977
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	800,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	800,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	654,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,000	Detroit Edison Co.	1963
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1974
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1972
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1973
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1973
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1974
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1970
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
* Site not selected.				
*	—	1,176,000	Tennessee Valley Authority	1977
*	—	1,176,000	Tennessee Valley Authority	1978

SITE	PLANT NAME	CAPACITY (Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1972
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1972
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	530,000	Jersey Central Power & Light Co.	1969
Lacey Township	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1975
Salem	Salem Nuclear Generating Station: Unit 1	1,050,000	Public Service Electric and Gas, N. J.	1972
Salem	Salem Nuclear Generating Station: Unit 2	1,050,000	Public Service Electric and Gas, N. J.	1973
Newbold Island	Newbold Nuclear Generating Station: Unit 1	1,088,000	Public Service Electric and Gas, N. J.	1975
Newbold Island	Newbold Nuclear Generating Station: Unit 2	1,088,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1971
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station	500,000	Niagara Mohawk Power Co.	1969
Rochester	R.E.Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Verplanck: Unit 1	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1976
*		821,000	Carolina Power and Light Co.	—
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1977
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 2	810,000	Cincinnati Gas & Electric Co.	1975
OREGON				
Rainier	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1971
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1973
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1975
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.–Ohio Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 1	810,000	Metropolitan Edison Co.	1971
Middletown	Three Mile Island Nuclear Station: Unit 2	810,000	Jersey Central Power & Light Co.	1973
*	—	1,052,000	Pennsylvania Power and Light	1977
*	—	1,052,000	Pennsylvania Power and Light	1979
SOUTH CAROLINA				
Hartsville	H.B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1970
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Rhea County	—	1,129,500	Tennessee Valley Authority	1976
Rhea County	—	1,129,500	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.-Green Mt. Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	780,000	Virginia Electric & Power Co.	1971
Gravel Neck	Surry Power Station: Unit 2	780,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Washington Public Power Supply System	1966
WISCONSIN				
Genoa	LaCrosse Boiling Water Reactor	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	527,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Central Aguirre	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1976

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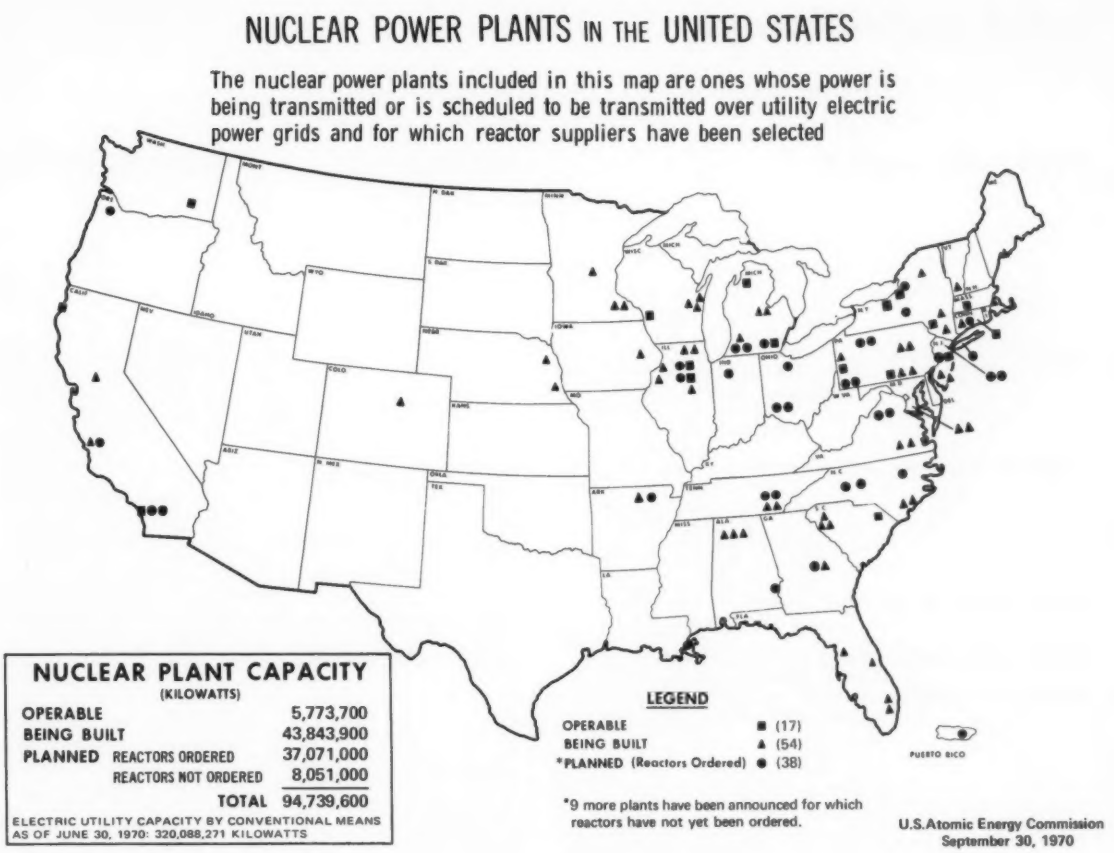
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The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 5,773,700
BEING BUILT 43,843,900
PLANNED REACTORS ORDERED 37,071,000
REACTORS NOT ORDERED 8,051,000
TOTAL 94,739,600
ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF JUNE 30, 1970: 320,088,271 KILOWATTS
LEGEND
OPERABLE ■ (17)
BEING BUILT ▲ (54)
*PLANNED (Reactors Ordered) ● (38)
PUERTO RICO
*9 more plants have been announced for which reactors have not yet been ordered.
U.S.Atomic Energy Commission
September 30, 1970

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOACTIVE CESIUM IN ESTUARIES. *Gordon K. Riel. Radiological Health Data and Reports, Vol. 11,* December 1970, pp. 659–665.

The concentration of dissolved cesium-137 from fallout in the Chesapeake Bay is on the order of 0.3 pCi/liter, while the concentration is less than 0.1 pCi/liter in the rivers and ocean that supply the bay's water. The ratio of radiocesium concentration to salinity in the bay is fairly independent of location and season. Brief studies elsewhere indicate that this pattern is typical of estuaries.

KEYWORDS: Cesium-137, Chesapeake Bay, estuaries, salinity, water

NASSAU COUNTY MICROWAVE OVEN STUDY, JUNE 1969–March 1970. *David Mafrici, Sheldon V. Bernstein, and Charles E. Miller. Radiological Health Data and Reports, Vol. 11,* December 1970, pp. 667–670.

The Radiological Health Section of the Nassau County Department of Health conducted a survey of microwave ovens located in Nassau County, New York. A total of 166 ovens were surveyed between June 1969 and March 1970. It was found that 23 of the 166 ovens (14 percent) exceeded the industry's standard of 10 mW/cm^2 during normal operation. When the door was in the process of being opened, 69 of the 166 ovens (42 percent) exceeded the standard. The owners and the manufacturers of the ovens were notified of the results of the survey and recommendations were made for correction of deficiencies.

KEYWORDS: interlock system, microwave leakage, microwave ovens, New York, radiation, survey

KRYPTON-85 LEVELS IN THE ENVIRONMENT DETERMINED FROM DATED KRYPTON GAS SAMPLES. *R. E. Shuping, C. R. Phillips, and A. A. Moghissi. Radiological Health Data and Reports, Vol. 11,* December 1970, pp. 671–672.

A program to monitor the krypton-85 atmospheric concentrations in the United States is described, and concentrations of krypton-85 at several sites are presented. A brief description of the analytical method is given and values obtained are compared with those reported or predicted by others.

KEYWORDS: atmosphere, environmental monitoring, krypton-85, liquid scintillation, United States

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